

REPORTS, PAPERS, DISCUSSIONS, AND MEMOIRS

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REPORTS, PAPERS, DISCUSSIONS, AND MEMORI

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Zoning

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JOURNAL OF LITERATURE

FACTORS IN THE ZONING OF CITIES

A SYMPOSIUM*

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* Presented at the meeting of the City Planning Division, Detroit, Mich., October 24, 1924.

ZONING AND HEALTH

By GEORGE C. WHIPPLE,* M. A. M. Soc. C. E.

INTRODUCTION

The word "zoning" is now commonly used to designate the governmental process of dividing municipalities into districts and imposing on private property in such districts, uniform building restrictions relating to height, bulk, and use. The New York Committee which set the pace in this matter was called by the descriptive title, "Committee on Building Districts and Restrictions", but the shorter expression seems to be preferred by the American public, even if the districts established bear little resemblance to mathematical zones.

It was natural and fitting that zoning should begin in New York, N. Y., because this largest of cities was suffering most from congestion, indiscriminate building, and the encroachment of private on public interests. The conditions were prejudiciously affecting the welfare of the community as a whole, working damage to property investments and personal injury to individuals. Zoning came to New York as a necessary act of salvation; but it is a measure the need of which has since become recognized in scores of American cities, witnessed by the two hundred and more zoning ordinances which have been passed during the last ten years. So general has zoning become that one may wonder why it is necessary at this late date to consider the fundamental reasons for it or seek to justify its constitutionality. It is not realized, perhaps, that Court decisions resulting from mandamus proceedings and involving the question of constitutionality are relatively few in number and not altogether in agreement. The legal status of zoning cannot yet be regarded as fixed, although each year appears to strengthen its standing. It is worth while, therefore, to consider some of the basic ideas which underlie the restriction of buildings by districts and without which zoning laws would be unsound.

In the typical zoning ordinance, provision is made for several height districts in each of which a limit is placed on the height to which buildings, or parts thereof, may be carried on established street lines, with provision for greater heights for parts of buildings back of certain established planes. From two to five or more height districts are commonly provided, with uniform regulation for each district, the street width being often used as the basis of the mathematical statement of height permitted. Bulk or area districts are covered by regulations which fix the percentage of the lot which may be occupied and the location and extent of open spaces in front of and around the building. Use districts differ according to the permitted or prohibited use of buildings or land, and are described by the words, "residential", "business", or "industrial". The various districts vary greatly in size and shape, and the three kinds of districts are rarely co-extensive; hence, in any zoned city, there are many combinations. As the movement progresses, there seems to be a

* Prof. of Sanitary Eng., Harvard Univ., Cambridge, Mass. Professor Whipple died on November 27, 1924.

tendency to simplify the law by making residence, business, and industrial areas the primary basis of classification, and subdividing each of these on the basis of height and bulk.

It is important that there be uniformity of regulation for each district, for without this the principle of equality before the law would be violated. It is important, also, that the zoning plan be a comprehensive one for the entire city.

Zoning is an essential part of city planning. Generally speaking, about three-fourths of the land area of a city is privately owned and subdivided into blocks and lots; the other fourth, devoted to streets, parks, etc., is owned by the municipality or dedicated to public uses. Again, speaking in generalities, municipal control of the public land is obtained through the governmental power of eminent domain, while municipal control over the use of private property is dependent on the exercise of police power. With rare exceptions, eminent domain has nothing to do with zoning; there is no question of compensation to the owner; no question of the necessity of acquiring private property for public use. The constitutionality of zoning depends on whether the restrictions proposed are justifiable under a reasonable use of the police power, a common law principle which, although undefined and undefinable, finds its backing in certain well recognized needs of the community. Used conservatively, the police power has to do only with injury to health, safety, or morals; used more liberally, it covers, in addition, such matters as the public order and convenience and even extends to what are called the amenities of life. With the increasing concentration of people in cities, there is good reason for the widening scope of the police power which has been witnessed during recent years.

Zoning is advantageous to a city in many ways. It tends to stabilize real estate values, to promote orderly building, to enhance beauty, and to develop local self-consciousness and civic responsibility on the part of the people. Yet, in the face of these benefits, zoning is likely to be declared by the highest Courts to be unconstitutional if it cannot be justified under the police power; and although instances may be cited where the police power has been exercised in a constructive manner to promote the general welfare of a community, its preponderant use has been to prevent injury to health, safety, morals, and—the lawyers like to add—“the like”. The purpose of this paper is to outline the scientific evidence bearing on the relation of zoning to health.

Health.—At the outset, it is important to grasp the full meaning of the word, “health”, to realize that it is more than the absence of disease; that it has a positive quality; and that it has to do with the mind as well as the physical body. It is useful to keep in mind the derivation of the word from the Anglo-Saxon “haelth”, which implied wholeness. If one were to venture a definition, it might be said that health is “that state or quality of life in which the body is sound, the various organs function naturally and the whole organism responds adequately to its environment.”

In a popular sense, public health means the general or collective health of the community. In an administrative or legal sense, it means the health of the community as influenced by factors which affect a considerable number of people in some connected way. The police power is not limited to public health

used in this restricted sense, but deals with health. Attention should be called to the fact that the adjective public restricts the word health instead of amplifying it.

Although it is difficult to define normal health, it is recognized that some factors tend to injure it, or lower its state, whereas other factors tend to promote it, or raise its state above the normal. Normal health presupposes a normal environment, the two ideas being complementary and inseparable. It is the purpose of zoning, as it is that of sanitation, to secure and maintain an environment in which normal human beings can lead normally healthful lives.

In an address* on "Sanitation—Its Relation to Health and Life", before the Sanitary Engineering Division of the Society, the writer pointed out that the principal injurious factors to health are infections, poisons, and accidents. The physiological factors, air, food, water, light, temperature and humidity, sleep, exercise, clothing, and shelter, and the sensory factors, smell, taste, sound, sight, and touch, are either health-promotive or health-injurious, according to their nature. This classification, indefinite though it is, serves to steady one's ideas when considering the complicated relations between health and environment.

Quantitatively, health can be measured only imperfectly and in part. Individual health may be expressed in terms of growth, height, weight, and other biometrical units. Community health on its negative side may be measured in terms of death rates and sickness rates, general and specific, for different classes, age groups, and particular diseases. No adequate methods of measuring community health, on its positive side, have yet been developed; perhaps they will come in time.

To a large extent, therefore, the subject under discussion is beyond the range of statistics; and reliance must be placed on accumulated experience and the opinions of competent authorities, rather than on logical scientific demonstration, although, in certain parts of the problem, scientific proof is available.

Indoor and Outdoor Conditions.—The relation between health and indoor life has long been recognized. Laws and ordinances covering the size and ventilation of sleeping rooms, drainage, dark hallways, cellars, windows, refuse disposal, and many other items, are common. Detailed building and plumbing codes, housing laws, tenement house laws and the like are in force in most cities. It is well recognized by the Courts that insanitary indoor conditions are prejudicial to the health of the people. It is coming to be recognized that, in important ways, indoor conditions are dependent on and controlled by outdoor environment. The light that enters a room through a window depends on the light that falls on the outer wall of the building, and this is affected by the position, height, and bulk of neighboring buildings. The quantity of air that enters a building is influenced, sometimes very greatly, by neighboring buildings, and the quality of the air is affected by what is going on in the neighborhood. In fact, nearly all the physiological and sensory factors related to health may be used to illustrate the close connection between indoors and outdoors.

* Proceedings, Am. Soc. C. E., April, 1924, Papers and Discussions, p. 490.

Placing restrictions on the height and bulk of buildings is virtually public control of the space outside the buildings. It prevents private owners from monopolizing light and air to which all people should have a common right. In some respects, time-honored conceptions in regard to property rights are faulty. It is assumed that lots of land privately owned are bounded by vertical planes which extend upward and downward without limit, unmindful of the fact that, in this latitude at least, the sun's rays fall slantingly on the earth and the winds blow horizontally. Building without limit on one's land, therefore, may interfere with a neighbor's use of his land and the enjoyment of certain bounties of Nature, thereby doing injury to his health and comfort. From this point of view, restriction on height and bulk appears to be justifiable.

Conversely, the indoor use of property may affect outdoor conditions. Buildings of great height and bulk lead to such indoor massings of people that not only are the means of ingress and egress provided with difficulty, but means of conveyance and the streets themselves become so congested that safety, health, and morals are jeopardized. Congestion may extend even to the substructures of the streets—the water mains, sewers, gas pipes, and electric light and telephone wires. Municipal governments, responsible for the streets and their use, cannot adequately perform their duties in the face of excessive developments of private property abutting on the streets. The indoor use of property, whether for residential, business, or industrial purposes, controls the character of the vehicular traffic and the character of the pavements required for it; it affects the cleanliness of the streets, as well as dust, odors, sights, and noises. The abutters and the public have common interests in the streets and public lands, which can be protected only by placing restrictions on the use of private property.

Phases of Life.—One of the primary purposes of zoning is to safeguard the conditions which affect three primary phases of life, namely, work, recreation, and sleep, each of which occupies about one-third of the adult's normal day. Adequate provision for work, sleep, and recreation (using this word in a sense broad enough to include rest and nourishment and not merely as a synonym for pleasure), is essential to health. The necessary conditions are not the same for all three, although for sleep and recreation they are not dissimilar. The keynote of work is efficiency; of sleep, quiet; of recreation, cheerfulness.

In infancy and old age, and with the sick of all ages, the conditions which favor sleep are especially important. During childhood and youth, when bodies are growing and minds are developing, the recreation phase controls. In middle age, the work phase predominates. To a large extent, the three phases of life are controlled by the sun—the day is for work, the night for sleep, and the morning and evening for recreation; but to an increasing extent, life in cities ignores the clock. Factories run continuously, night work is required in many ways, transportation never ceases. Those who work at night must sleep by day. What was once a "time" separation is fast becoming a "place" separation. To obtain normal, healthful conditions in cities, home life must be separated in place from work life, and, in order that permanency be given to this separation, a certain amount of governmental control of private property is essen-

tial. This is the basic principle which underlies building restriction by districts.

In making this place separation, it is necessary to take into account various practical considerations. Many people like to live within walking distance of their work, and the daily walk, if not too long, is one of the positive factors of health. Home life requires that the grocer, the butcher, the baker, and other neighborhood conveniences be not too far away. Certain associated businesses gain in efficiency by segregation. Some kinds of manufacturing involve processes which are noisy or which give rise to odors, bearable during work, but offensive from the standpoint of home life. Cities which have been built under the doctrine of *laissez faire*, cannot be rebuilt in a day. These and similar facts have led to the establishment of zones of the most irregular shape, size, and position, zones not always topographically logical, but the best that can be established under the circumstances. The need of zoning is the best argument in favor of city and regional planning.

The primary object of zoning, therefore, is (1) to protect the basic phases of life against injury by providing adequate place-separation of residence, business, and industry; and (2) to prevent the private monopoly of natural light and air, necessary to health, by restricting the height and bulk of buildings in ways appropriate to their neighborhood.

With these general principles in mind, various factors involved in the problem, namely, light, air, noise, odors, congestion, and the like, will now be discussed in some detail.

Light.—The rays of the sun bring light and heat to the earth and both are necessary to man's existence. Dr. Haven Emerson, paraphrasing Michelet, has tersely epitomized human experience by saying, "You cannot raise babies any more without light and air than you can raise plants." Although admittedly mysterious in its action, sunlight is of positive biological benefit and this is true even of diffused sunlight, or daylight. Its action is both physiological and psychological. It is a natural stimulant to the skin and the nervous system. It aids naturally in providing resistance to the body against diseases like tuberculosis. It has recently been learned that it plays an important part in the cure and prevention of rickets in children. It helps to cure tuberculosis of the bones. It provides illumination, the absence of which hampers activities of mind and body and induces eye-strain with its attendant damages and discomforts. It provides warmth in winter. Although science has not yet fathomed the influence of the sun's rays (and this influence may perhaps include the rays beyond those of the spectrum of light), it is a matter of accumulated experience that sunlit rooms are not only cheerful, but healthful, and that dark rooms are gloomy and unhealthful.

There are likewise many indirect benefits. Sunlight is a powerful disinfectant, rapidly destroying bacteria exposed to it, whether floating in the air or resting on pavements, floors, or walls. Unequal heating of the air induces convection currents and beneficial air movements. Places not exposed to sunlight are more likely than others to contain stagnant air. Air movements have an important influence in regulating the temperature of the body. Stagnant

air around the body tends to increase in humidity, thereby making a person feel warmer in summer because of lessened evaporation and cooler in winter because of greater conduction of heat by the moist air.

Sunlight tends to reduce the relative humidity of the air by increasing its temperature and its ability to hold water vapor. By removing moisture from dust particles in the air, it tends to lessen fogs. It also tends to dry pools of water which otherwise might become breeding spots for mosquitoes.

Sunlight markedly influences vegetation. Trees, shrubs, and grass are natural automatic regulators of heat conditions. During the summer, trees produce desirable shade, yet, in winter, they do not obstruct the sunlight. In this respect, the shade of trees differs from the shade of buildings. Vegetation also provides a natural chemical balance. Human beings, as well as all animals, inhale oxygen and exhale carbonic acid; whereas plants in sunlight take in carbonic acid and give out oxygen. Vegetation cannot thrive without sunlight and water. It is a matter of history that the increasing height of buildings and the increasing extent of impermeable area due to buildings and pavements, drive out trees, shrubs, and grass. The effect of vegetation is local. Trees and grass concentrated in parks cannot take the place of vegetation on streets and individual house lots.

Daylight, which means indirect lighting from the sun by reflection from the sky, the clouds, and various surfaces, does all these things, but to a less degree than direct sunlight. Sunlight may even be too great, as every one knows, especially during the summer and in the tropics. Daylight has an important economic value. It is not only beneficial physiologically and psychologically, but increases the productiveness of labor and reduces the necessity of artificial illumination. Artificial illumination involves expense and must be arranged with great care in order to be effective and not cause injury to the eyesight. Lighting with oil or gas tends to vitiate the air by increasing the carbonic acid and moisture, and even by increasing the poisonous carbonic oxide.

Artificial lighting also increases fire risks. Lack of proper exterior lighting increases the window space required and this, in turn, increases the heat loss in buildings in winter.

There are abundant reasons, therefore, for stating that adequate provision for allowing daylight to enter an inhabited building is essential to human growth, health, vitality, and comfort. Whoever, by building overmuch on his own land, prevents his neighbor from receiving a reasonable amount of light on his land is doing him an injury that properly comes within the scope of the police power.

Much can be done to make the best use of sunlight by the orientation of buildings and streets. Buildings facing the cardinal points are not as well lighted throughout the year as those facing the quarter-points. Western townships with their north, south, east, and west boundaries have tended to grow up into cities having streets in these directions. Many trivial matters often control street orientation, whereas the element of sunlight receives scant attention. The matter does not become one of real importance until high

buildings are constructed, and, by that time, street lines have become fixed. Contact with civil engineering students in recent years has convinced the writer that astronomy receives too little attention in the schools. Few students, on graduation, are able to trace the sun's path in the heavens at different seasons or to draw the shadow of an isolated house, not to mention the shadows of high buildings on each other, when located on a street of given latitude, width, and direction.

Air.—The necessity of pure air need not be argued. It is a fundamental principle registered by human experience. Modern studies of ventilation emphasize the physical properties of the air—temperature, humidity, and movement—and their physiological importance. These heat relations are closely linked with the problem of sunlight, already considered.

Nothing in recent experimentation, however, controverts the need of cleanliness of the air we breathe. Dust in the air tends to irritate and clog the breathing apparatus. If the dust particles are sharp, as in the case of silica, they wound the delicate membranes so that bacterial infection is likely to follow. Statistics of tuberculosis among stone-cutters show that this disease is prevalent in direct proportion to the percentage of silica in the stone dust. Dust may injure the eyes and clog the pores of the skin. Its damage is economic as well as physiological. The extent to which disease germs are transmitted from person to person through the air is not well known. Ordinarily, spray from the mouth or nose does not carry more than a few feet, and accompanying bacteria capable of detection by present methods do not live long in the air because of the destructive effect of drying and sunlight. The behavior of the filterable viruses in air and the longevity of the spores of bacteria, moulds, and fungi, however, are only imperfectly understood. Irritating fumes from chemical processes may be not only offensive to the senses, but also cause physiological injury. Any air which by reason of dust or bacteria, irritating fumes, or offensive odors, tends instinctively to induce shallow breathing, must be regarded as injurious to health. Just as pure air tends to promote health by naturally inducing deep breathing and stimulating the bodily functions, so exposure to vitiated air tends to break down the individual's power to resist disease, especially respiratory affections, such as colds, pneumonia, and tuberculosis. Here, the element of time is important. A fleeting bad odor may be offensive, but do little or no injury, whereas some odors, long continued, may be injurious. On the other hand, there are odors to which people become accustomed and which do no damage. Individual susceptibility plays an important part in the phenomenon of odor. The extent to which foul air affects breathing during sleep appears to be not well known from experimental studies, but judging from experience, its influence is quite as important as during waking hours.

The air which enters a building, both in quality and quantity, is influenced by the neighboring buildings and by the streets. Intakes of ventilation systems are more often located with reference to indoor distribution than to exterior conditions which affect the quality of the entering air.

Many studies have been made of the number of dust particles and bacteria in city air, both in the United States and abroad. The absolute figures need not be considered because their order of magnitude varies according to the methods used and the sizes of the dust particles included in the counts. Relatively, the tests agree in showing that dust in the air is greatest near the street and decreases logarithmically upward; that macadamized streets and much traveled granite pavements produce more dust than streets sheet-paved; that dust is closely associated with the cleanliness of the streets and methods of cleaning; that automobile traffic produces less dust than horse traffic, but distributes it to a greater extent; that street cars raise dust one or more stories higher than horse traffic; that less dust is found over grass land than pavements; that less dust is found in residential districts than in business or industrial districts, etc.

Smoke is another important source of dust. The use of oil-burners in place of coal-burners is changing this problem. The Mexican oils are higher in sulphur than American oils, and their use increases the sulphurous fumes in the air to a measurable extent.

Where high buildings exist, the ventilation of streets is coming to be an important problem. If buildings are high relative to the street width, there is likely to be a stagnation of air over the pavement and a concentration of dust, bacteria, foul odors, and automobile smoke, injurious to the health of persons using the streets.

The density of automobile traffic in cities is already so great that traffic officers are sometimes overcome by the poisonous fumes of carbonic oxide, and pedestrians are greatly inconvenienced by the smoke. In business districts, where large trucks are used and traffic is heavy, these conditions are especially bad, and are at their worst when associated with high buildings with flat roofs and overhanging cornices. If the streets have a marked grade, there is a tendency for gravity currents to produce partial ventilation with dilution of the bad air; but when they are level, gentle winds do not suffice to effect the necessary ventilation of deep, cavernous streets. Strong winds, on the other hand, produce excessive currents through cavernous streets, that are very objectionable in winter.

In the interest of air purity, therefore, zoning is justified. Residential districts, where people sleep and recreate and where children grow up, need protection against the atmospheric dirt of the business and industrial districts.

Noise.—Susceptibility to noise in general and to particular noises varies greatly among individuals. It is a difficult question to discuss. It is well-known that noises hinder sleep. Physicians say that certain persons, especially those suffering from nervous diseases, are seriously injured by noise and vibration. Every one knows that in many ways noises interfere with the comfort and tranquillity of life. Quiet is especially important at night, in residential districts, and near hospitals and schools.

Noises are greatly increased by the reflection of sound waves from the hard surfaces of pavements and building walls. Limitation of the height of buildings is, therefore, a means of noise reduction. Vegetation, on the other

hand, tends to dampen sound waves—another reason for providing conditions favorable for trees and grass in residential districts.

Many kinds of noises are preventable, but others appear to be inseparable from traffic, business, and manufacturing processes. In these cases, segregation appears to be the best solution.

Congestion.—Congestion, or crowding, needs to be viewed from at least three angles as far as health is concerned, that is, room crowding, land crowding, and personal contact.

Room crowding is commonly expressed as a ratio of the number of square feet of floor area, or number of cubic feet of room volume, per person. Minimum limits are sometimes placed on one or both of these ratios for sleeping rooms, barracks, schools, factories, etc., based on the hygienic need for light, air, and ventilation—matters which have already been considered.

Land crowding, expressed as so many persons per acre, introduces two additional elements, the number of stories and the area of the building with reference to the size of the lot and the street width. One of the most important reasons for restricting the height and bulk of buildings by districts is to prevent overcrowding of corridors, elevators, streets, and sidewalks. These have to do more with questions of safety and accident than with normal health, questions not considered in this paper.

The third phase of congestion bears directly on the spread of disease. When people are brought into such close contact that opportunity exists for breaths to intermingle, as in crowded elevators and cars, or for the nasal spray of one person to pollute the air breathed by another, there is serious danger that disease germs may spread and that colds and respiratory diseases may become epidemic. It may be true, as medical bacteriologists claim, that crowd exposure tends to build up an acquired immunity against certain diseases so that to some extent Nature protects itself, but the fact remains that, on the whole, crowding speeds up and increases the transmission of disease. It is a menace to health, morals, and safety.

No one has yet established a logical basis of street capacity, either for pedestrians or vehicular traffic, or the relation which an adequate street capacity should bear to the size of abutting buildings. Most streets in American cities were laid out to accommodate slow-moving traffic and buildings of two, four, or six stories, or thereabouts. Increase in building height has led to serious street congestion in many places. Fragmentary data exist as to the number of square feet per person in buildings used for different purposes, the permissible capacity of elevators, the space occupied by moving pedestrians under different conditions, and the street space monopolized by vehicles of different character moving at different speeds. These data should be assembled and studied with a view to establishing, if possible, some reasonable relation between building size and street area. The writer's unsatisfactory attempt to do this (too meager to warrant publication), has convinced him that the fundamental data need first consideration.

Psychological.—Health is mental as well as physical. Mental health is intangible, but none the less real. Sunlight is beneficial largely because it is cheerful. Trees and grass and flowers are healthful for the same reason. The

beauty of form, color, light, and shade conduce to mental health. Eyes are rested by a change of focus and ears by a change of sound. Monotony causes mental fatigue, and carried to the yielding point, may cause insanity. Children, especially, need opportunities for proper development and adjustment of the senses, but all workers like to get away from their work at night. A most important benefit of zoning is to provide opportunities for the changes necessary to normal mental health.

Community Health.—It is easy to object to particular applications of the zoning principle. Building restrictions of necessity must be arbitrary. Boundaries of districts must be actual lines, and in establishing lines where conditions grade almost insensibly one into another, it is difficult to avoid individual injustices. It is often difficult to show that zoning prevents injury to the health of certain particular individuals. There are various matters for adjustment and administration which should be provided for, as well as may be, in zoning laws. Although zoning as a principle has abundant justification under the police power, it must not be forgotten that since Magna Charta, the individual has had protection against undue restrictions of government in what is known as "due process of law".

The relation between zoning and health is a mass relation. It is the health of the community, the collective health of many people, that is at stake. Families rightly separate working quarters from sleeping quarters; cooking and eating and sleeping in the same room is regarded as insanitary. Tenement-house laws, factory regulations, building codes, and the like, safeguard the internal uses of the buildings. The zoning law does for a city what some of these laws do for the factories, schoolhouses, and dwellings.

When cities grow without plan, their constituent districts tend to change in character. Single houses give way to apartment houses; residential districts are insidiously invaded by business and manufacturing; and old buildings are converted to uses for which they were not intended and for which they are ill adapted. Converted houses are notoriously likely to be insanitary and unhealthful. In a growing city, there is a natural tendency toward concentration for economic reasons. A person who erects an apartment house in a region where only single dwellings exist, is capitalizing for his own pocket-book, light, air, and the other residential benefits at the expense of his neighbors. A single-house region once infected with an apartment house tends to accumulate other apartments, and the neighborhood tends to change from a stable, house-owning population to a shifting, renting class, a class lacking in neighborliness and civic pride and leading an impoverished family life. Thanks to sanitation and other modern improvements, apartment-house life has been made healthful for adult existence, but the compressed and repressed life of a modern city apartment is not conducive to growth or to a life that is full and rich. Segregation of apartment houses is justified as a measure for protecting community health.

Gradually it is dawning on men's minds that cities which grow to great size do so at the expense of the health and comfort of their own citizens; that rapid growth which outruns municipal ability to make or remake necessary

thoroughfares and provide needed public utilities, leads to ugly confusion, whereas a slower, well-ordered growth is more likely to lead to civic beauty and a better civilization. The United States is entering on a period of lower population increase. As pride in growth and quantity production lessens, as it must, the elements of stability and self-control and beauty need to be strengthened.

Zoning should be regarded as a sort of collective self-control, a means by which a city controls its own life and growth for the best good of all its citizens. It is an act of police power fully justified in the interest of morals, safety, and health.

ZONING FOR USE

BY EDWIN A. FISHER,* M. AM. SOC. C. E.

INTRODUCTION

The comprehensive paper† by Morris Knowles, M. Am. Soc. C. E., on "The Purpose of Zoning Ordinances, and Methods of Administration," and his equally admirable contribution to the subject of zoning presented at the Annual Meeting of the Society, January 19, 1923,‡ cover the general subject of zoning very fully. The speaker, therefore, will confine himself to a description of methods and accomplishments of zoning for use in the City of Rochester, N. Y.

THE ENABLING ACT

In Rochester, zoning for use is done by the City Planning Bureau acting directly by authority of the Legislature, as shown in the following provisions of the City Charter:

"*Section 290.—City Planning Bureau.*—The City Planning Bureau is in the Department of Engineering, and the chief officer thereof is the Superintendent of City Planning appointed by the City Engineer to hold office during his pleasure. He has power, with the approval of the City Engineer, to appoint to hold office during his pleasure such subordinates as may be prescribed by the Board of Estimate and Apportionment." (C. 505, L. 1917.)

Section 291 defines the powers and duties of the Superintendent of City Planning, as follows:

1.—The Superintendent has power to accept streets.

2.—The Superintendent must approve of all plans for opening, widening, extending, or discontinuing streets, or fixing the widths of pavements or sidewalks.

"3.—It is the duty of the Superintendent of City Planning to prepare a city plan and to set forth thereon streets which the proper development of the city requires to be opened, widened, extended or discontinued, and the width thereof; also the sewer systems necessary to be constructed or extended, and the water mains necessary to be laid or extended, and the location of buildings, docks, parks, playgrounds, school houses and municipal buildings. Such plan shall cover the territory embraced within the boundaries of the City of Rochester and also all territory within one mile of such boundaries, and such further territory outside of the city as the Superintendent may deem proper. Such plan may be made in parts from time to time covering different portions of the city or territory outside of the city. Amendments, alterations and additions to said plan or plans may be made from time to time."

Paragraph 4 of Section 291 refers to zoning for use and reads:

"4.—The Superintendent of City Planning has power to divide the city into districts and to regulate, restrict and prohibit the location of businesses, trades and industries, and the location or alteration of buildings or struc-

* Cons. Engr. to the City of Rochester, Rochester, N. Y.

† See p. 178.

‡ "Zoning—Its Progress and Application", *Transactions, Am. Soc. C. E.*, Vol. LXXXVI (1923), p. 1349.

tures designed for specified uses or of a certain character or class in any such district. A portion of a street may form or be a part of any such district. Residence districts may be created in which shall be permitted only single-family dwelling houses or dwelling houses or residences containing accommodations for such number of families as may be deemed proper. Specified businesses, trades or industries may be permitted in one district, and others excluded therefrom, and special regulations may be prescribed for the business, trades or industries so permitted in such district. Regulations, restrictions and prohibitions in one or more districts may differ from those of other districts. The use or occupation of a building or structure in any district must not be changed so as to be in violation of the regulations, restrictions or prohibitions applying to such district. Such regulations, restrictions and prohibitions shall be designed to promote the health of the public, for the safety and welfare of the inhabitants of the city, for the promotion of the growth and prosperity of the city, and to secure the proper development and upbuilding of the city." (C. 505, L. 1917.)

Section 292 of the charter refers to the City Planning Advisory Board, and reads:

"The City Planning Advisory Board consists of the Corporation Counsel and the four members appointed by the Mayor, and it must annually elect one of its members president thereof, and has power to adopt rules and regulations for the transaction of its business, and to hold public hearings upon matters coming before it, and it must hold a public hearing upon the written request of two members. It is the duty of the Superintendent of City Planning to submit all fixations of the width of pavements and sidewalks and all proposed plans and the proposed formation of zoning districts and regulations in reference thereto, and proposed action with reference to accepting, opening, widening, extending and discontinuing streets, to the City Planning Advisory Board, and upon approval by the Board, the same become effective. In case any such matter so submitted is disapproved by the City Planning Advisory Board, the Superintendent may present the same to the Mayor, and the Mayor, after a public hearing, may approve the same, and it thereupon becomes effective." (C. 524, L. 1921.)

Section 293 provides for the employment of experts:

"Employment of Experts."—The Superintendent of City Planning has the power with the approval of the Mayor to employ experts for specific work or for a specified period of time not extending beyond the expiration of the fiscal year, whose compensation must be fixed by the Board of Estimate and Apportionment, but in each instance the expert so employed must first be approved by the City Planning Advisory Board." (C. 505, L. 1917.)

* * * * *

"Section 295.—Violations, How Punished."—Any person violating any rules, regulations, restrictions or prohibitions made by the Superintendent of City Planning and duly approved, as provided in this article, shall be guilty of a misdemeanor, and on conviction thereof shall be punishable by a fine not exceeding one hundred fifty dollars, or by imprisonment not exceeding one hundred fifty days, or by both such fine and imprisonment, or by a penalty of five hundred dollars to be recovered by the City of Rochester in a civil action." (C. 524, L. 1921.)

As amended in 1921, Section 126 provides that the City may maintain action in the Monroe County Court, the Supreme Court, and other Courts of record of competent jurisdiction to restrain violations of penal and other ordinances of the Common Council, and of rules, regulations, restrictions,

and prohibitions made by the Superintendent of City Planning and duly approved.

As amended in 1921, Section 202 provides that before the owner of any tract or parcel of land in the City of Rochester sells or conveys any part thereof in subdivisions of such tract or parcel, he must cause a map of such tract to be made, which map must first be approved by the Superintendent of City Planning and by the Advisory Board before it can be filed in the office of the County Clerk, etc.

It will appear, therefore, that the Superintendent of City Planning has greater power, and more extensive duties, than is usual for a City Planning Commission. City Planning Commissions usually report to the Common Council or other legislative body of the city. For the City of Rochester, the Superintendent reports his action to an Advisory Board composed of four citizens, appointed by the Mayor, also the Corporation Counsel, *ex officio*. The action of the Board is final, except that an appeal may be taken by the Superintendent to the Mayor. The Advisory Board, pursuant to the authority granted, has adopted rules of procedure, one of which will permit any property owner aggrieved by the action of the Superintendent to bring the matter directly to the Board for a hearing. This rule was adopted at the request of the Superintendent. Members of the City Art Commission may be appointed to the Advisory Board.

METHOD OF PROCEDURE IN ZONING FOR USE IN THE CITY OF ROCHESTER

Atlas maps, uncolored, of the entire area of the city were procured, and on these maps the actual use conditions of all the property was shown in colors. After a study of these maps, and numerous hearings before various organizations, the zoning for each particular section of the city was shown on a tracing superimposed on the map and strongly fastened thereto.

This was found to be a very useful method of procedure in designating the various zones. These maps have been preserved and amended from time to time, and are of great use in exhibiting to any property owner the reasons for the zoning as shown on the tracing. They are in constant use in the office of the Superintendent.

The rules and regulations for "use" districts are similar to those in other cities. The "use" districts into which the city is divided consist of six classes, known as Unclassified Districts; Unrestricted Districts; Industrial or Manufacturing Districts; Commercial or Business Districts; Residential Districts Class D, and Residential Districts Class E.

It will be noted that Residential Districts are divided into two classes, the first class, or Class E, provides for single or two-family dwellings, double houses or Boston flats, clubs, churches, convents, schools, libraries, private offices of a physician, surgeon, or dentist, railroad passenger stations, real estate signs referring to the property on which they are maintained, recreational buildings in public parks and playgrounds, farming, truck gardening, nurseries, and greenhouses; also, for purposes necessarily or ordinarily access-

sory to such usage, as, for example, a private garage for not more than four motor vehicles.

The other class of Residential Districts, referred to as Class D, covers, in addition to the uses specified in Class E, tenement houses, hotels, lodging houses, boarding houses, etc.

The rules and regulations for "use" districts, together with the maps made a part thereof, were presented by the Superintendent to the Advisory Board and approved by the Board on September 22, 1919. Zoning for use, therefore, has been in force in Rochester for four years.

The speaker acted as Superintendent of City Planning from the inception of the work until January 1, 1924, in addition to his duties as Consulting Engineer, and since January 1 has been more or less familiar with the operations of the Bureau as Consulting Engineer.

In a discussion* on "City Planning" before the Annual Meeting of the Society on January 19, 1923, the speaker gave a brief description of the work in Rochester to that time. He stated as his belief that "zoning that cannot be changed without too much trouble had better not be done."

The rules and regulations of the City Planning Bureau in Rochester provide for changes and exceptions. Among these provisions are the following: The Superintendent of City Planning, with the approval of the Advisory Board, shall have the power to construe these rules and regulations liberally to bring about the greatest public good. From time to time, on his own motion, or on petition, after public notice and hearing, the Superintendent, also, with the approval of the Advisory Board, may amend, supplement, or change the rules and regulations and the districts as established on the "use" maps.

If the owners of 50% or more of the frontage in any street between intersecting streets present a petition to the Superintendent of City Planning requiring a change or repeal of regulations provided for such frontage, the Superintendent must present the petition to the Advisory Board which must act upon it within a period of not more than sixty days.

Exceptions.—The Superintendent, with the approval of the Advisory Board, may, in writing, authorize exceptions to the "use" rules and regulations, when he deems such exceptions to be necessary for the public good:

"The erection in a residential district, for a period of not more than one year from the date of such authorization, of a temporary building for commerce or industry incidental to the residential development.

"The issuance of a temporary and conditional authorization for not more than two years for structures and uses in contravention of the requirements of these Rules and Regulations in undeveloped sections of the city.

"The enlargement of an existing structure or use, or the erection on the same lot of an additional structure for a lawful use existing at the time of the adoption of these Rules and Regulations, not conforming to the Rules and Regulations of the Use District in which it is maintained, when such alteration, extension or addition is determined by the Superintendent of City Planning not to be detrimental to, or tend to change, the character of the neighborhood.

* *Transactions, Am. Soc. C. E., Vol. LXXXVI (1923), p. 1375.*

"The establishing of a public garage, public gasoline station, or both, or a stable for more than three horses, in any class residential district upon presentation of written consent of the owners of not less than 75% of the frontage of all real property within 200 ft. of the lot upon which the said use is proposed, where, in the opinion of the Superintendent and the Advisory Board, such use will not be detrimental to, or tend to change, the character of the neighborhood. On a corner lot the frontage shall be measured on the street to which the use proposed is to have vehicular access. In computing the percentage of consents required under this provision, the frontage of lots having a usage of a public garage, public gasoline station, or a stable for more than three horses, shall be counted as consenting. A map or plan of the entire property drawn to scale upon which said use is requested, showing the location of existing and proposed structures or buildings upon the premises, and the location of driveways and entrances from the public street or alley, must be submitted with each application, which map shall be kept on file in the office of the Superintendent of City Planning. (Amended November 27, 1922.)

"The establishing of a public garage, public gasoline station, or stable for more than three horses, in a Commercial District, after notification to the owners of frontage on both sides of any street to which said garage, station, or stable is to have vehicular access for a distance of 200 ft. of the lot on which said use is proposed, provided that whenever a written protest against such garage, station, or stable, duly signed and acknowledged by the owners of 20% of the frontage herein specified has been presented to the Superintendent of City Planning, the Superintendent will present the same to the Advisory Board, which will act upon said protest within a period of not more than 60 days after the filing of the same by the protestants with the Superintendent of City Planning. (Amended November 27, 1922.)

"The establishing of a telephone exchange or electric sub-station in a Residential District where such use is determined by the Superintendent of City Planning not to be detrimental to, or tend to change the character of, the neighborhood.

"The erection of an accessory structure in a Residential District, or in a Residential District Class E, other than as provided in Section 6 or Section 7 of Article III, where in the opinion of the Superintendent and the Advisory Board, such use will not be detrimental to, or tend to change, the character of the neighborhood. (Amended February 13, 1922.)

"The erection and maintenance of commercial and industrial uses other than hereinbefore prescribed in a Residential District, or in a Residential District Class E, subject to appropriate conditions and safeguards, and where, in the opinion of the Superintendent and the Advisory Board, such use will not be detrimental to, or tend to change, the character of the neighborhood." (Amended February 13, 1922, after a decision of the Court of Appeals construing the New York City regulations.*)

Acting under the authority granted by the Legislature and the Rules and Regulations of the Bureau, the Bureau has granted exceptions for various purposes. It will be noted that the regulations prohibit gasoline stations and garages in Residential or Commercial Districts, except by consent of the Bureau. From the time the regulations took effect in September, 1919, to January 1, 1924, the Bureau has granted exceptions for 106 gasoline stations, an average of about 26 per year, nearly all in Commercial Districts.

A careful investigation of every application for a gasoline station is made by the Superintendent, and the applicant is required to file sufficient plans to show the general features and appearance of the building. The type of

* People ex rel Sheldon vs. The Board of Appeals, etc., 234 N. Y., 484.

construction of buildings used for that purpose is now much better than when the Bureau began its operation.

Any garage having a capacity for more than four cars is called a public garage; therefore, when a property owner desires one or more additional cars he must proceed in the same manner as if he were asking for a large public garage. The total number of exceptions granted for garages to January 1, 1924, is 140; 118 in Commercial Districts and 22 in Residential Districts. Of the latter nearly all were for one or more additional cars.

Among other exceptions may be mentioned tailor shops, in both Residential and Commercial Districts. The manufacture of ready made clothing is a large industry in Rochester. In the Residential District, both the manufacturers and employees desire to use small buildings not more than two stories in height for this industry. The Bureau, therefore, at the request of the residents, made exceptions for such purpose. To January 1, 1924, 56 exceptions have been granted for this purpose; 16 in the Commercial Districts and 40 in Residential Districts.

CHANGES OF ZONE

Although no general changes in zone have been made, there have been numerous minor changes. These changes were made largely in the part of the city that is changing from Residential to Commercial or Industrial. One reason for many of the changes is due to the fact that, in preparing the original zoning of certain streets which evidently would be entirely business in the near future, the Superintendent subdivided the street allowing those parts occupied by good residences to be classed as Residential, and the remainder as Commercial. In many cases the demand for additional business has exceeded expectations and changes have been necessary. To January 1, 1924, there have been 173 changes in zone—mostly minor changes, and largely from Residential to Commercial.

As stated previously, the City has no separate and distinct Board of Appeals. The Advisory Board acts as such Board and gives careful consideration not only to matters brought before it by the Superintendent, but also to any matter brought before it by any citizen under the provisions of the special rule heretofore referred to.

Use zoning is generally approved by the citizens of Rochester. Its success is due largely to the high character of the members of the Advisory Board.

COURT APPEALS

In Rochester, only three cases have been appealed to the Courts, and a decision has been reached on one only. The first case related to an alleged discrimination in denying an application of one person for a gasoline station and granting the application of another in the same district. It had no relation to the general question of zoning.

The second case, now in the Courts, questioned the right of the Bureau to change the zone from Residential to Commercial.

The third, and most important case, was an application of a property owner for a mandamus to compel the Superintendent of Building to grant a permit

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for the erection of an apartment house in a part of East Avenue zoned as Residential Class *E*, that is, for one or two-family houses. In this action, the constitutionality of zoning was raised. The Court, in denying the application, said:

"The Court will take judicial notice that East Avenue is the chief residential street of the city. With these assumptions and under the allegations in the petition, the sole question is whether the city may prohibit the erection of apartment houses in the portion of East Avenue in question, not this particular apartment house, but any apartment house. If the statute and rules are unconstitutional, of course no application to the Superintendent of City Planning and Advisory Board was necessary and the petitioner would be correct in his position that the Superintendent of Building could be compelled to grant a permit, but the statute and rules are not unconstitutional. The use of private property is not unrestricted under the Constitution and the Legislature may from time to time add new restrictions which are reasonably necessary. It cannot be said that the present restrictions as to apartment houses are unreasonable or unnecessary or that they are without the purpose of the statute or the powers of the Legislature.

"The provisions of the Constitution as to the taking and use of private property are to be construed in the light of existing social conditions and advancing social necessities. The powers of a municipality under legislative authority to limit and restrict the use of private property has been sustained in many cases and zoning statutes, ordinances, and rules, substantially similar to the ones involved on this application, have been upheld. The papers, therefore, raise no question of fact and upon the facts stated are insufficient as a matter of law."

AREA ZONING

BY HARLAND BARTHOLOMEW,* M. AM. SOC. C. E.

The remarkable spread of zoning in American municipalities has been due primarily to the popularity of the use regulations. Many ordinances deal exclusively with use regulations, and a few embrace use and height regulations. Where use regulations are not the sole concern, attention and discussion usually center about height regulations. Area regulations are seldom questions of particular concern or public discussion.

Of the 261 zoning ordinances in effect in American cities, according to the latest bulletins of the U. S. Department of Commerce (August 30, 1924), 138 contain area regulations as part of a comprehensive zoning ordinance. The cities possessing ordinances with area regulations are divided, as follows:

California	6	Nebraska	1
Connecticut	1	New Jersey.....	42
Delaware	1	New York.....	24
District of Columbia.....	1	North Carolina	1
Georgia	1	North Dakota.....	1
Illinois	20	Ohio	11
Indiana	3	Oklahoma	1
Kansas	2	Pennsylvania	1
Maryland	1	Rhode Island.....	1
Massachusetts	10	South Carolina	1
Michigan	3	Tennessee	1
Minnesota	2	Washington	1
Missouri	4	Wisconsin	1

The literature of zoning contains very little data on area zoning. Study of a large number of ordinances containing area regulations reveals great lack of uniformity of practice, and one may seek in vain for any important decisions in the higher Courts on the area provisions of zoning ordinances.

Area zoning is an almost untouched field. One of the best informed attorneys engaged in zoning practice is of the opinion that all zoning will succeed or fail in the Courts depending on whether it can be justified as an exercise of the police power in the interests of public health. This implies that area regulations in zoning ordinances are of equal, if not of greater, importance than the use or height regulations. Considered in conjunction with use or height regulations, area zoning is not of secondary importance.

A brief study of the application of area zoning in cities leads one into the whole field of land economics and housing, which to-day are world problems. Are these not worthy of the consideration of the engineer? Is any one better equipped to solve and interpret these problems? The improper adjustment of dwellings to land in cities produces social and economic problems

* Engr., City Plan Comm., St. Louis, Mo.

of great magnitude and is the primary cause of much of the wasteful and unscientific methods of city building.

An examination of the maximum, minimum, and average density of population per unit of land area in a considerable number of large cities is sufficient evidence that overcrowding of land is not an economic necessity. Various forms of housing accommodations (that is, tenements and residences) are needed for certain proportions of the population in any city. The present wide diversity of accommodations and types of dwelling construction may be attributed largely to the lack of a proper understanding of desirable standards that might be produced by proper area zoning as a part of a comprehensive zoning and city planning program. It must be frankly admitted that there are no proper standards generally accepted as such to-day. Although much intelligent and sustained effort has been expended in the preparation of housing laws, it must be admitted that what might be termed satisfactory housing laws have been enacted in only five or six States and, even in these, overcrowding of the land has proceeded apace. Examination discloses no well defined lines of demarcation between housing laws, tenement house codes, building codes, and zoning ordinances in various cities and States.

In the Central-Western and Southern States, it is not uncommon to find cities in excess of 100 000 population without housing laws, building code, or zoning ordinance. In cities of less than 50 000 or 75 000 population, it is not uncommon to find the most lackadaisical enforcement of any housing or building code regulations that may exist. Growing cities usually witness a gradual decrease of home ownership and lowered housing standards. A vast proportion of the population in large cities (those who through force of necessity or otherwise are "renters") never appreciates nor is in a position to demand good housing accommodations. Land subdividers and builders are more often concerned with maximum economic returns than with the provision of desirable housing standards. The speculative apartment-house building that has accompanied the post-war period well illustrates this fact. In one large city, apartment houses built in 1921 provided approximately 625 sq. ft. of lot area per family (ranging from 400 to 1 200 sq. ft. of lot area per family). In this same city, in 1922, of all the apartments constructed only two provided densities of less than 200 sq. ft. of lot area per family housed. In 1923, in the same city, the tide turned backward and of all the apartments constructed only two structures were built which provided less than 400 sq. ft. of lot area per family. This is a typical example of the fact that good housing standards are entirely secondary to maximum economic returns on anything for which the public can be made to stand. In this particular case, the public was squeezed on the land until it rebelled and began to demand and secure larger accommodations.

In attempting area zoning the first inquiry is whether present practices with their constantly changing vagaries shall be accepted, or whether preferably an attempt should not be made to establish proper standards and limitations. This is no easy task. It involves conflict with structures previously constructed without proper regulation, and conflict with the land and building

speculator who invariably resents any attempt at regulation. It also implies proper adjustment between housing laws, building codes, and zoning ordinances. The city planner cannot ignore the inter-relationship of these three important means of creating desirable dwelling construction. Each in itself is sufficient to meet completely the problems with which the city planner wishes to deal. They must be simultaneously considered and co-ordinated.

As a basis for discussion it is suggested, therefore, that each State enact a proper housing law and that each city adopt a proper building code and zoning ordinance. It is further suggested that the housing law concern itself with questions pertaining to sanitation and proper interior design; that the building code provide for proper forms of construction in the interest of public safety; and that the zoning ordinance provide for the placement of buildings on lots, the regulation of light and air through open spaces within and about buildings, the regulation of building heights, and the segregation of buildings according to types of use.

If the foregoing suggestions can be accepted, the next consideration should be the provisions that should be included in the zoning ordinance in zoning for area.

Front yards (sometimes called "building lines" or "set-backs"), side yards, rear yards, and courts constitute the open spaces about buildings and would appear to be legitimate forms of zoning for area. Their exact determination, however, is somewhat dependent on the homogeneity of districts which implies co-ordination of use and height regulations. The regulation of percentage of lot occupancy by buildings and control of density of population may also conceivably influence the design of open spaces and, therefore, are properly elements of zoning for area.

Before further discussing the exact nature of these forms of regulation the speaker will mention the matter of land subdivision. Probably the most prolific fundamental cause of bad housing, as well as of other evils, is the widespread method of subdividing land into streets and lots of more or less uniform or standardized sizes, regardless of topographic conditions, position in the city structure, and probable use. The exact nature of land use and its early development would seem to be a prerequisite of land subdivision. More and more realtors are coming to realize the importance of this self-evident fact. Land subdivision rules which seek to create a proper subdivision of land in accordance with its ultimate use are being adopted by the city planning authorities. The realtor who subdivides properly, who develops and restricts his property with due regard to its position in the city structure, has accomplished all and more than the city planner. It is failure to complete this full operation that leads to conflict and misunderstanding, to wasteful and inappropriate development of property.

To interject further, it must be recognized that the modern city is so vast and intricate an organic structure that to function with any degree of efficiency and satisfaction it must have unity of plan. Land subdivision and zoning are elements of the comprehensive city plan. They cannot be considered alone. If this is a curb on individual liberty or enterprise, its com-

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pensation is greater public and community benefit and convenience. In practice, it still permits of unlimited initiative and enterprise in the development of private property with reasonable, if not unlimited, economic return. City planning and zoning direct rather than restrict the use and enjoyment of private property, and the total cumulative result is greater, rather than less, economic return, not to mention the larger compensations of improved living and working conditions.

Zoning for area, therefore, necessarily implies consideration of the entire city structure and its plan. It implies determination of standards compatible with good housing. Styles of dwellings vary in different cities and even within each city. Some considerations are offered as follows.

Front Yards.—Front yards should not be required in commercial or industrial areas under zoning ordinances. If the streets are too narrow to admit adequate light and air, the building height should be restricted in accordance with studies of sunlight projection for buildings intended for human occupancy.

Front yards should be required in multiple-dwelling districts in order that living quarters may be removed from the noises of the street and from the dust and gasoline fumes caused by the larger volume of traffic usually incident to such districts. A front yard of 15 or 20 ft. would not seem unreasonable for a multiple-dwelling district for reasons previously mentioned, and incidentally would give opportunity for a lawn and planting at least suggestive of, and reasonably compatible with, a home. If the streets are narrow, front yards increase the opportunity for better air circulation and the degree of privacy within apartments fronting the street.

Front yards are desirable in single-dwelling districts because of lessened noises, dust, and fumes from the street, increased privacy, general amenity, and improved character, appearance, and stability of the neighborhood. A front yard of 20 or 25 ft. would seem to be a reasonable requirement and is the customary standard. Buildings on corner lots should recognize the front yards of side streets.

Side Yards.—Side yards should not be required in commercial or industrial districts. If side yards are provided and buildings or parts thereof are intended for human occupancy such yards should be sufficiently wide to admit of adequate light and air, based on studies of sunlight projection. The width of a side yard should be related to the height and length of the building and the minimum width should permit of easy access in case of fire. Narrow side yards are usually damp, dark, refuse collectors and, as such, are a menace to health.

Side yards should be provided on either side of multiple dwellings that have windows of individual apartments opening thereon. Access and egress in case of fire, privacy of apartments, and ample provision of light and air would justify widths of 12 ft. or more, depending on the design of the structure, as there is often little or no distinction between side or rear yards in multiple dwellings.

Side yards should be provided on either side of detached or semi-detached dwellings for access in case of fire, for privacy, and for general amenity,

character, appearance, and stability of the neighborhood. A minimum of 5 ft. should be required for sanitary reasons.

Rear Yards.—Rear yards should be required in commercial and industrial areas to permit within the interior of blocks an open space common to all structures. This would facilitate the provision of light and air to all structures intended for human occupancy. This is especially true where numerous buildings occupy a single block. Exceptional conditions often make impossible the realization of this ideal. Where alleys are provided and buildings generally seek light and air from the front and rear, this requirement is not impossible of realization. It is a more simple and satisfactory method than that of attempting to provide light and air for each structure on its own lot. Rear-yard dimensions should be based on sunlight projection and, consequently, should be proportionate to the building height.

Rear yards should be provided for all multiple dwellings, preferably of not less than 25 ft., to create adequate open spaces within block interiors for air circulation, privacy of apartments, and to facilitate access and egress in case of fire. Rear yards are needed for service entrances and garages. In intensively developed multiple-dwelling districts where people are crowded on the land it is often impossible for a city to provide adequate recreation spaces, and it would not be unreasonable to require a certain amount of open space in proportion to the families housed. This might be provided in the rear yard if not elsewhere on the lot.

Rear yards should be provided for single dwellings for reasons of privacy, light, and air, and for garage or accessory buildings. A rear yard of 25 ft. is a reasonable and customary standard in the average type of residential lot.

Courts.—Where provided to supply light and air to buildings intended for human occupancy, courts should be proportioned, in size, to the height of the building based on studies of sunlight projection.

Percentage of Lot Occupancy.—Opinions differ as to the desirability and effectiveness of regulations governing the percentage of lot area that may be covered by buildings. In New York, N. Y., this type of regulation has been useful in preserving the integrity and desirability of the single-family, detached dwelling districts. In cities where large lots are the custom, this type of regulation is more or less ineffective if not unreasonable. If used, this regulation should accompany yard and court regulations.

Population Density.—Families per Acre.—Control of population density, expressed in terms of families per acre, or square feet of lot area per family, is a most desirable form of area zoning. It prohibits overcrowding of land that is otherwise difficult to control. It encourages uniformity of land occupancy and, as such, should permit easy improvement of housing standards. It furnishes a logical point of departure for scientific city design, and a sound basis for utility design and for the construction of public improvements.

Objection has been expressed to population-density-regulation because of the varying sizes of "families", the unit of regulation. This is objection to method, not principle, and implies the need for a better form of expression or definition of terms. Public health, public safety, and public morality demand

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certain control of density of population in accordance with the type of dwelling. Public convenience is substantially promoted thereby.

Whereas the limits of this paper do not permit of extended discussion of this subject, the regulations given in Table 1 will admit of good housing standards, although each should be accompanied by forms of open space regulations dependent on the particular design.

TABLE 1.

Type of building.	Square feet per family.	Number of families per acre.
Detached or semi-detached single-family dwellings.....	4,000	10
Single-family dwellings in rows or blocks.....	2,000	20
Single and double flats, 2 and 4-family (St. Louis, Mo., type)	2,000	20
Multiple dwellings	1,250 to 625	34 to 68

Conclusion.—The considerations given in this paper are offered more to suggest a basis for discussion of zoning for area than to recommend particular regulations. Each city offers a somewhat different problem in the social organization, habits, and customs of its people and form of dwelling construction. The form of zoning for area that will best promote good housing and living conditions should be studied for each city. Forms of housing that have proved their desirability should be preserved. New forms better adapted to modern conditions and to preserving good standards should be encouraged.

A wider understanding of the importance of minimum standards of good housing is needed. The honorable practice of land subdivision, improvement, development, and sale will thereby be promoted and dishonorable, wasteful, and inappropriate practices, discouraged and defeated.

THE PURPOSE OF ZONING ORDINANCES AND METHODS OF ADMINISTRATION

By MORRIS KNOWLES,* M. AM. SOC. C. E.

SYNOPSIS

There is a growing appreciation and understanding by engineers of the importance of zoning regulations as a part of city planning. Much has been accomplished in zoning activities since January, 1923, and this paper attempts to call attention to some of the pitfalls and the dangers and the wisdom of a sane consideration of regulations before attempting to put them into effect.

The principal purpose, however, is to call attention to some of the administrative measures and to point out the lessons derived from some experiences, not only in the review and preparation of zoning regulations, but also in the actual operation and application of ordinances to given circumstances. Particular stress is laid on the necessity of starting right and this means: First, a comprehensive enabling act; second, careful study and preparation of data; third, thorough discussion with every one affected; fourth, the administration of such ordinances by capable and honest officials; and, fifth, the interpretation of special clauses in particular cases by a competent Board of Appeals, actuated by a sense of justice, fairness, and an humanitarian feeling toward all those who are affected.

PROGRESS OF ZONING

One of the sessions of the Annual Meeting of the Society in January, 1923, was devoted to the subject of City Planning, at which the speaker presented a paper entitled, "Zoning—Its Progress and Application".† At that time, attention was called to some of the necessary requirements in the production of a wisely drawn zoning ordinance.

Statistics.—At the beginning of 1923, zoning regulations were in effect in 129 municipalities and, in September, 1921, when the Advisory Committee on Zoning was organized in the Department of Commerce, only 48 cities and towns, with less than 11 000 000 inhabitants, had adopted zoning ordinances, and only 18 States had enabling acts. During the three years prior to July 1, 1924, zoning regulations had been adopted by 210 municipalities, the total number at present in the United States, being 258 cities and towns. Of these, 63 have a population of less than 5 000; 48 with more than 5 000 and less than 10 000; 40 with more than 10 000 and less than 25 000; 42 with more than 25 000 and less than 50 000; 47 with more than 50 000 and less than 250 000; and 18 have a population exceeding 250 000. The total number of people living in zoned commu-

* Pres. and Chf. Engr., Morris Knowles, Inc., and Chairman, Pittsburgh City Plan Comm., Pittsburgh, Pa.

† *Transactions, Am. Soc. C. E.*, Vol. LXXXVI (1923), p. 1349, et seq.

nities is 24 000 000, or 44% of the urban population of the United States. All but seven States now have enabling acts in some form. It is of interest to note the popularity of zoning regulations in the small towns, which frequently zone without competent advice and do the bizarre thing.

The statistics just given indicate the strong appeal which zoning has on the hearts of the people. There is a growing tendency, and an increasing belief on the part of all, that this expanding application of the police power has come to stay. There is a feeling on the part of the small home owner, that in no other way can ample protection be provided; on the part of the realtor, that wise and sane development can best take place; on the part of mortgage lending and insurance companies, that stability will be brought about; and on the part of city engineers, planners, and municipal executives, that only in this way, can the future development and needs of the city, with the necessary improvements and utilities, be provided without waste and with the prudent expenditure of public funds.

Official Education.—All this has been a matter of education and advancement of public sentiment which, in turn, is reflected in the decisions of the Courts. This naturally is to be expected in the interpretation of regulations on such a subject invoking the application of the police power. Much of this public education and sane development of zoning regulations has been brought about by the activities of Herbert Hoover, M. Am. Soc. C. E., Secretary of the Department of Commerce of the United States. On taking office, Mr. Hoover early realized that a proper labor of his Department would be the promulgation of information for the education of the people of urban communities regarding the wise exercise of their activities and prudent expenditures of money by thoughtful city planning, of which zoning regulations are a large part.

The publication and issuance of the Standard Enabling Act, in August, 1922, resulted in a large number of States either passing new Acts covering this subject, or making substantial amendments to several of the Acts already in existence. The recent publication of the pamphlet analyzing the zoning ordinances of the sixteen typical cities which had passed zoning ordinances prior to November, 1922, has resulted in bringing to the attention of many people, the variety of the regulations relating to use and height, which are the subjects thus far covered. It is to be expected that such information and the discussion therefrom will prevent many cities from attempting fanciful and visionary types of ordinances which are the results of personal whims, or idiosyncrasies of local people. Such regulations are all too likely to be thrust aside by the highest Courts as an improper exercise of the police power.

Kind of Regulation Desired.—The type of restriction needed is that which, although not going as far as some would like, will still give to different groups of people the kind of control desired in the particular community. That which is sane and goes only so far will be a step of progress, but will not advance to an extent that is likely to be upset by the Courts. Zoning is a growing subject and as the people become familiar with the regulations, administrative officers become experienced in its operation, all become familiar with what can, and what cannot, be done; the Courts also will come to realize that every step is

the result of careful consideration and a wholesome regard of the public need and welfare. Then that stability which arises from certainty will be obtained, and the reversal and throwing into the scrap heap of certain types of attempts which have occurred too often in the past, will be obviated.

At one time the speaker made the assertion that:

"Zoning will stand or fall as a result of the care in its preparation and the degree of fairness used in its interpretation and appeal to all owners that it will produce beneficial results to the property of all as the years go by. Much, therefore, depends on its application and interpretation in a broad spirit without fear or favor during its early development."

An early Roman edict on stone tablets states that "The welfare of the people is the highest law". Both statements are as true now as when they were made.

REQUIREMENTS FOR GOOD ADMINISTRATION

Although not strictly coming under the head of administration, it is quite as true in this field of endeavor as in every other, that a false start generally results in failure. As was said by Secretary Hoover in his foreword to the Standard Enabling Act, "The importance of this Standard State Zoning Enabling Act cannot well be over-emphasized."

Standard Enabling Act.—It is apparent, after careful consideration, that there is danger in not having a complete and comprehensive enabling act (and it is doubtful whether home rule city charters will ever be a sufficient substitute therefor). Such an enabling act should carefully state the grant of power in all detail; the method of dividing the municipality into districts; the procedure to be followed by the municipal legislature; the requirements as to careful, comprehensive, and detail study; the need of publication and hearings before adoption by municipal legislature; the provision for amendments and modifications, under careful restricted requirements as to notice and vote when certain percentages of the people protest; the provisions for a Board of Adjustment which shall have the power to vary the ordinance and grant exceptions in harmony with its general purpose and intent and in accordance with certain rules and under appropriate conditions and subject to the proper safeguards; also, the provision for remedies and penalties.

The importance of the grant of power is appreciated when it is realized that all the regulations as to use, height, area, and the details covering questions of occupancy and location; size of yards, courts, and other open spaces; percentage of lot occupancy and density of population, should be carefully stated in the Act. This is necessary in order to show that such limitations apply and are subservient for the purpose of promoting the health, safety, morals, or general welfare of the community. Section 3 of the Standard Enabling Act is quoted for the purpose of showing the necessity of exercising such care in drafting an ordinance:

"Section 3.—Purposes in View.—Such regulations shall be made in accordance with a comprehensive plan and designed to lessen congestion in the streets; to secure safety from fire, panic, and other dangers; to promote health and the general welfare; to provide adequate light and air; to prevent the over-

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crowding of land; to avoid undue concentration of population; to facilitate the adequate provision of transportation, water, sewerage, schools, parks, and other public requirements. Such regulations shall be made with reasonable consideration, among other things, to the character of the district and its peculiar suitability for particular uses, and with a view to conserving the value of buildings and encouraging the most appropriate use of land throughout such municipality."

Study and Procedure.—Careful study is necessary in order that the division of the municipality into districts, of any desired size and shape, is best suited to carry out the purpose of the regulations. Such districts, however, should indicate, by their very expression, that they are uniform for each class or kind of buildings throughout the particular district. This does not mean that districts, particularly those required for use, may not be as small as desired, namely, as small as one block or the corner lot within the block, provided reason is exhibited in the specification of such regulation. This particular detail is important because of the all too frequent misunderstanding illustrated by the one item of use. Some have thought that the regulation with regard to residential districts of considerable size does not permit the introduction of the convenient neighborhood store. This, of course, is erroneous because, in some districts, certain areas, particularly corner lots, can be appropriately zoned for the neighborhood store with the proper height and area regulations.

Some municipalities have disregarded the important question of procedure and, therefore, it is necessary to state this quite carefully in the enabling act. Thus, anxious and hurried groups of people will not attempt to pass zoning regulations without careful study, without thorough-going discussion, and without having hearings, with a sufficient notice in order that all can be advised. If there is any one thing that should be impressed on the advocates of zoning it is that much time must be given to public education and consideration.

One reason for the advisability and even necessity of public discussion is to avoid misunderstandings as to what zoning is for, how it originated, and how it really works. Much unfortunate, ill-advised, erroneous criticism has come from those who really wish to deceive because they do not believe in fair play. Lawrence Veiller, Secretary and Director of the National Housing Association, calls these "poison gas attacks". They relate to the assertion that zoning was "made in Germany", with the apparent feeling that such will damn it forever. The American people, however, are too intelligent to be moved by such assertions, even if true, because anything worth while from any country warrants thorough study and consideration to determine how far it may be applicable to American conditions.

The facts, however, are quite at variance. Zoning was practiced in France in 1810, at the time of Napoleon, more than half a century before it was applied in Germany. A recent Scandinavian student of the subject is said to have traced zoning to Italy and France as far back as the Fifteenth to Seventeenth Centuries. As early as 1667, the height of buildings was limited in Paris. Dr. Evans, of Chicago, Ill., states that the earliest known instances of zoning were the establishment of the ghettos in which the Jews were required

to live. These ghettos were districts outside the walls of the ancient cities. Zoning of to-day, however, is an American product suited to American conditions.

Amending Machinery.—The safety and stability of zoning regulations are dependent on the machinery by which amendments can be made. Zoning will always be a live subject, just as the growth of municipalities is a live and virile thing. There never will be stagnation; there should be no desire to prevent progress. Amendments to any such machinery of administration are likely to be desired and, in the progressive change and development of the municipality, it is evident that streets and districts will naturally change in character of use, calling for amendment. It should be possible, therefore, to have the provisions for making such amendments as reasonable as possible; but they should be safeguarded, also, so that, due to sudden whims or at the request of favored property holders, the desire to make amendments which may injure others, should not be too easily accomplished.

The well established method of doing this is to provide that there shall be sufficient notice before an amendment can be considered by the legislative authorities of the municipality. Frequently, the body which first studies the zoning ordinance (be it a Planning Commission or a Special Zoning Commission) is called on first to consider such amendments and then report to the municipal legislature. In this way, there will be avoided that hasty and ill-considered action which fails to take into account the relation to other provisions of the ordinance and the effect on other properties in the district, or even on other districts. Then, again, if there are protests, it is necessary that a larger vote of the municipal authorities be required. Generally, a three-fourths vote of all members is required, in case there is protest of 20% of the owners of the area included within the enclosed change, or those immediately adjacent in the rear thereof, or directly opposite thereto, extending a certain number of feet from the width of the lots to be affected.

Board of Appeals.—Of all the rocks on which zoning has been shattered and become ineffective, the inability to have a Board of Adjustment (sometimes called Board of Appeals) is perhaps the one most frequently in evidence. A review of the decisions of the Appellate Courts, which have denied the application of zoning in particular cases, shows that, although there has sometimes been lack of interpretation of the modern spirit of the application of the police power to this subject, in the majority of cases such adverse decisions have generally resulted from an inadequate enabling act. This has either not been sufficiently detailed and comprehensive, with sufficient safeguards, or has not provided this Board of Adjustment which, in its operation, permits a flexible and kindly modified regulation of so strict an instrument in a humane and appropriate way. No city is entirely free from special conditions, with peculiar topography and physical arrangements. Watercourses, hills, irregular shape of industrial districts, long time existing but incongruous business and residential districts, all call for special treatment with great consideration and care.

It is, therefore, proper and necessary that some body, other than the Courts, first be given the chance to review and to interpret, in necessary cases,

the application of the zoning ordinance where undue hardship and severity of the execution would ensue. Such Board of Adjustment should be authorized by the Enabling Act, in order that it may be legal for the municipal legislature to delegate such a grant of power. Otherwise, the municipal legislature is incompetent to extend such provision to any such Board. Such a Board may have as large a membership as seems necessary, generally from three to five members who should have rotating terms of office and may or may not be paid, as in each municipality seems wise. It should have certain stated fixed meetings and, although adopting rules for its own procedure, should be compelled to keep minutes of its proceedings, record votes, and have its records open to examination.

The Standard Enabling Act suggests that such Board shall have the following powers:

"1. To hear and decide appeals where it is alleged there is error in any order, requirement, decision, or determination made by an administrative official in the enforcement of this act or of any ordinance adopted pursuant thereto.

"2. To hear and decide special exceptions to the terms of the ordinance upon which such board is required to pass under such ordinance.

"3. To authorize upon appeal in specific cases such variance from the terms of the ordinance as will not be contrary to the public interest, where, owing to special conditions, a literal enforcement of the provisions of the ordinance will result in unnecessary hardship, and so that the spirit of the ordinance shall be observed and substantial justice done."

Such provisions do not mean that remedies are exhausted. There should also be the provision that an appeal will lie to any Court of competent jurisdiction from such Board of Adjustment. The operation of such a Board will materially relieve the duties of the Courts, and perhaps in 99 cases out of 100, will do away with the necessity of Court proceedings. If a case does reach the Court there is less likelihood of the provisions and principles of the zoning act and ordinance being stricken down, because it will be evident that at every step of the way the aggrieved person has had sufficient opportunity for a careful consideration of his particular case.

Remedies.—The enabling act should include the ordinary provisions for penalty for violation. These may not be a serious deterrent to a person desiring undue privileges. An additional power, therefore, should be granted to local authorities to institute appropriate action or legal proceedings to prevent the unlawful erection or construction, alteration, conversion, or use of any property in violation of the provisions of the zoning ordinance.

ADMINISTRATIVE AGENCIES

It is customary to provide that the administration of the zoning ordinance shall fall on such municipal officer who has been in the habit of enforcing regulations regarding building construction, such as building codes, plumbing codes, fire ordinances, etc. In some cities, such officer may be called the Superintendent of Building Construction or the Building Inspector. In some communities, it may be the City Engineer or the Director of the Public Works,

and, in some smaller communities, it may be the officer in charge of Public Safety, or the head of the Police or Fire Bureau.

Enforcing Official.—In any case, it must be understood that such administrative officer has no power of discretion. He reads the ordinance and the maps which accompany it, which show, by suitable symbols and designations, the application of the text of the ordinance in certain districts of the city. His word is final, except for the ordinary provisions of Court appeal, as to the issuance of a permit. However, where provisions are made for the Board of Adjustment (and as before stated, this is an absolutely necessary provision), the decisions of this administrative officer are subject to review and change by the action of such Board. No longer does the decision of the executive officer become final and the Board always exists to modify or vary whatever he may have said.

Experience in Pittsburgh, Pa., shows that, almost without exception, a denial of the application of the Superintendent of Building Inspection results in an appeal. Whether this will always continue, with a growing understanding and appreciation of the ordinance, is yet to be determined; but at least in the early experience of the ordinance, this seems to be the natural and expected thing.

In the early period of the administration it is to be anticipated that such executive officer and his force will not have the knowledge of the details of the ordinance, its intent, and its application, as thoroughly as they will after it has been in use for some time. It is to be expected, therefore, that some mistakes will be made, that the owner will not take "No" for an answer. Until he learns the spirit of the Board of Appeals and its method of operation, he will always try to have such an order changed or modified. Real estate operators, contractors, and owners will all learn in time just what can be accomplished under the law and in certain districts. It is quite possible, therefore, that in the future there may be less work for the Board of Appeals.

Effect on Building.—It will be of interest, in this connection, to review the results of the operation of the zoning ordinance in Pittsburgh, as exemplified by certain statistics, which include the activities of the Board of Appeals. The zoning ordinance of Pittsburgh, which city has a population of about 626 000, became effective on August 9, 1923, and the Board of Appeals was appointed and began its activities on September 5, 1923. Up to August 1, 1924, the Board of Appeals has received 964 applications, of which 889 have been acted on, in one way or another. The City of New York, with a population of 6 000 000, had 624 cases in the calendar year 1923, of which 167 remained undetermined on December 31, 1923, leaving 457 as acted upon.

In Table 2, there is presented the total permits granted for the twelve months prior to August 1, 1923, and for the period ending July 31, 1924. This also shows permits for new dwellings. Table 2 also shows the number of cases presented to the Board of Appeals for each of the twelve months ending July 31, 1924. Of these appeals occurring within the twelve months, 635 affected use, 11 affected height, 310 affected area, and 8 affected a combination of two or more of these restrictions.

TABLE 2.—COMPARISON OF BUILDING PERMITS IN PITTSBURGH, PA., BEFORE AND AFTER PASSAGE OF ZONING ORDINANCE.

Months.	BUILDING PERMITS.				APPEALS.	
	AUGUST, 1922-JULY, 1923.		AUGUST, 1923-JULY, 1924.		August, 1923, to July, 1924.	Percentage of appeals.
	Total.	Dwellings.	Total.	Dwellings.		
August.....	590	68	557	132		
September.....	542	135	491	92	49	10.0
October.....	561	122	656	167	67	10.2
November.....	487	110	545	174	65	11.9
December.....	313	114	500	158	72	14.4
January.....	292	89	355	120	70	19.8
February.....	336	129	424	144	70	16.5
March.....	688	271	651	216	71	10.9
April.....	836	241	911	240	140	15.4
May.....	811	193	945	216	124	13.1
June.....	713	157	909	179	104	11.4
July.....	755	143	788	166	132	16.8
Total.....	6 874	1 766	7 732	2 004	964	12.4
Percentage increase.....	.....	.....	+ 12.5	+ 13.5	.....	.....
*Permits in 65 cities.....	353 250	186 212	402 122	208 391	.....	.....
Percentage increase.....	.....	.....	+ 13.8	+ 11.8	.....	.....

* Of 68 cities having population of 100,000 or more, July, 1923, to June, 1924, inclusive.

Table 3 shows the disposition of all appeals for the year ending July 31, 1924. It is apparent that by far the greater number of appeals are granted either completely or with conditions.

Because of the peculiar topographical conditions in Pittsburgh, the limited area devoted to business within the triangle bounded by two rivers and Grant's Hill and the congested river-bank area devoted to industry, it is apparent that there will always arise a number of cases which must be reviewed by such a Board of Appeals.

Character of Amendments.—The question of changes in amendments has already been thoroughly discussed, but a brief review of the indications of that which may happen generally, even with the most carefully drawn ordinance, may not be amiss. It must be taken for granted that, with the greatest discussion and publicity that can be obtained, zoning ordinances will be passed that are not understood by a large number of people. As soon as the application is felt and the pressure applied, many will object and feel aggrieved; thus there early arises a desire for several types of amendments.

In almost all cases these early requests arise through misunderstanding and inability to appreciate what can be accomplished; sometimes from a desire to accomplish anything that personal whims dictate; sometimes this comes from a lack of public spirit and unwillingness to estimate properly the ill effect on adjoining owners and sometimes from purely mercenary motives and the desire to get all the money possible from a given investment. This results

in requests to the friendly councilman to introduce an amendment to correct the supposed error.

TABLE 3.—DISPOSITION OF APPEAL CASES IN PITTSBURGH, PA.,
FROM AUGUST 1, 1923, TO JULY 31, 1924.

Months.	Total appealed.	Granted.	Granted with condition.	Denied.	Held over.	Revoked.	Withdrawn.
August.....	...	...	...	...	...	...	...
September	49	7	7	9	26	...	...
October	67	10	30	21	31	1	...
November.....	65	10	38	20	27	...	1
December.....	72	13	24	21	40	...	1
January.....	70	20	26	23	41	...	...
February	70	19	35	15	41	...	1
March.....	71	20	32	23	37	...	...
April.....	140	36	57	26	57	...	1
May.....	124	34	62	26	59	...	...
June.....	104	24	46	31	62	...	...
July.....	132	22	60	37	75	...	...
Total	964	215	417	252	75	1	4
Percentage of total.....		22.3	43.2	26.2	7.8	0.1	0.4

During the early history of the zoning ordinance it would be well if as few amendments as possible are presented, or if they are presented, that they receive such careful and long-time consideration as will prevent stampeding. If too many amendments are made at once, the impression is likely to be created that zoning regulations are ephemeral, that they are due to immature consideration, and that they ought to be wiped out wherever they run counter to private desire. The usual machinery for amendment is such, of course, as to prevent hasty consideration, but even with such precautions, some amendments will be requested which should never have been presented. The longest time history of a zoning ordinance on record is that of New York, which was passed in 1916, and the story of adopted amendments, which is presented in Table 4, is interesting.

Table 4 shows that, for the first four years during which the zoning ordinance was in effect, the number of amendments passed were largely those of a nature to lessen restriction. Beginning in 1920, the restrictive amendments have been increasing both in number and in percentage, until at present they outnumber the relaxing ones three to one. Perhaps this is the natural development to be expected. If an ordinance has been carefully drawn and wisely administered, the people will appreciate its beneficial effects. Although there may be some tendency in the beginning to object, the general pressure of public opinion which is effective and which appreciates stability and desires protection, will see to it that only those amendments will be passed which are helpful and in sympathy with the spirit of the ordinance. It is too early, from a statistical point of view, to determine the result in Pittsburgh, but it is believed that the effect will be similar. Only twelve amendments to the Pittsburgh zone map have thus far been presented.

TABLE 4.—CHANGES GRANTED BY YEARS IN GREATER NEW YORK
ZONING PLAN.*

Year.	Number of changes.	RELAXING CHANGES.		STRENGTHENING CHANGES.		RATIO : STRENGTHENING TO RELAXING CHANGES.
		Number.	Percentage.	Number.	Percentage.	
1916	4	4	100	0	0	0
1917	43	36	84	7	16	19
1918	26	20	77	6	23	30
1919	20	13	65	7	35	54
1920	27	12	44	15	56	125
1921	38	15	39	23	61	153
1922	61	14	23	47	77	336
1923	81	19	23	62	77	326
Total..	309	133	44	167	56	126

* Some amendments include more than one change.

RESULTS FROM APPLICATION

It was stated during the consideration of the Pittsburgh zoning ordinance that the passage of such regulations would have an adverse effect on building operation. A study of Table 2 indicates the contrary. The total building permits during the last half of 1923 and the first of 1924—following the adoption of the zoning ordinance—exceeded the total during the preceding year by 12.5%; and those for dwellings by 13.5 per cent. For comparison with general conditions throughout the country, the permits for 65 of 68 cities having a population of 100 000 or more—as recorded by the Department of Labor—have been studied. The increase during the period from the middle of 1923 to the middle of 1924, over the preceding year, was 13.8% for the total and 11.8% for residences. It will be noted that, in general construction, Pittsburgh differed little from the general average throughout the country; but showed a rather marked increase in the construction of new dwellings. This would indicate confidence in the protection of home neighborhoods by the zoning regulations. In fact, there is a growing belief in the city that such ordinance has come to stay; that it is helpful rather than damaging to wise building activity; and that property values have been stabilized. The ordinance has probably won friends rather than made enemies through its administration.

Personnel of Appeal Board.—The policy and methods of the Appeal Board may have contributed somewhat to this situation. The Board is composed of three members appointed by the Mayor. One, the manager of one of the four large estate holdings in the city, which owns large unimproved as well as improved land, represents the real estate interests and brings to the Board a sane and conservative view with regard to the uses of property. Another member is the Secretary of the Retail Merchants Association; he is also a member of the Transit Commission, Secretary of the Flood Commission, and has had the experience of broad public connections. The third, a member of the City Planning Commission, and also a real estate operator, acquainted with conditions which obtain with the small home owner and renter,

is familiar with the drafting of the ordinances, the consideration given to the various parts, and the public discussion given to each. Thus, the Board, wisely constituted and actuated by earnest purposes, considers every question on its merits and with a friendly spirit of enforcing the ordinance without undue harshness.

This Appeal Board started with the idea of visiting every property on which an appeal was taken, and from the beginning has held weekly sessions. The number of cases has varied from fifteen to thirty-five each week. Monday afternoon is devoted to hearings, at which the testimony of the applicant and protestants is taken. Wednesday is devoted to consideration and dictation of the decisions and re-hearings, if any. Friday afternoon is devoted to a consideration and signing of the decisions as written and the listing of cases to be heard on the next Monday. Visitations are made after such listing and before the case is heard on the following Monday.

Court Appeals.—Only four cases have been appealed to the Courts in Pittsburgh, and decisions on two have been reached. The first case is one of an appeal by certain property owners against the granting, after review by the Board of Appeals, of a permit for the construction and operation of an incinerating plant in a light industrial district. It should be stated that the ordinance provides that such authority to issue a permit is granted to the Board of Appeals, but not to the Superintendent of the Bureau of Building Inspection, under the following listed powers of the Board of Appeals: "For the use of land and the erection and alteration of buildings in a Heavy or Light Industrial District for the incineration of refuse or rubbish in properly constructed furnaces." After careful study on appeal from the denial by the Superintendent of Building Inspection, the Board of Appeals caused a permit to be issued for the erection of such a building with the following conditions:

"1.—That the owner provide on its own land sufficient storage facilities for twenty (20) truck loads of material, so that there will not be any occasion for the stopping of trucks in Juniper or other streets in the neighborhood of the premises while awaiting turn to be unloaded.

"2.—That nothing in this permit shall carry the right to use for any purposes the land within the lines of Juniper and Neville Streets as located at the front and rear of the property.

"3.—That the unloading, receiving, and charging facilities be under cover and be such as to prevent nuisance, uncleanliness or dust, or the accumulation of material, débris, or ashes; and that suitable ventilation be provided, so that dust which comes from unloading can be taken through into the settling chambers, or stack, by means of suction fans or otherwise.

"4.—That the furnaces be sufficient to consume the maximum amounts of material rapidly and at temperatures sufficiently high to prevent odors and with sufficient size of dusts, settling chambers, and stack to have a slow enough velocity and with stack high enough to produce the necessary draft and not carry odors, gases, or dust to the top thereof and discharge over the neighborhood."

On the grant of such permit on appeal the aggrieved property owners in the vicinity took the case to the Common Pleas Court of Allegheny County on the plea that:

"(1) The decision of the Board is illegal on the grounds that the Acts of Assembly and the Ordinance of the City of Pittsburgh are unconstitutional and void;

"(2) The decision of the Board of Appeals violates the provision of the Act creating the Board of Appeals;

"(3) The decision is in violation of the sections of the ordinance which prohibits incinerating plants in light manufacturing districts;

"(4) The Board of Appeals had no jurisdiction to grant permit until plans and specifications of the proposed incinerating plant had been filed, showing the exact type, style, location, kind of material, and furnace to be used;

"(5) The Board heard about three or four witnesses of the objectors, that twenty were present and ready to testify. This decision is arbitrary and against the weight of the evidence."

The Court decided on February 12, 1924: (1) that grounds of illegality specified by the objector should not be sustained; and (2) that the Board acted in compliance with the ordinance legally adopted in pursuance of legislative authority and exercised legal power given it by the ordinance. This case has been appealed to the Supreme Court of Pennsylvania and will be heard publicly in January, 1925.

The second case, which is somewhat more complicated, arises out of the illegal act of the petitioner in enclosing a front porch on his house. The definitions of the ordinance provide that a porch is a roofed open structure, projecting from the front, side, or rear wall of the building. A front yard is one extending across the full width of the lot, from the front line of the building to the front line of the lot. Thus, an enclosed porch becomes part of the building, and the depth of the front yard must then be measured from the face of the projecting front porch which has become the front wall of the building.

The owner, without securing a permit, proceeded to enclose his porch. Various complications and misunderstandings arose because of this illegal act. Proceedings were entered to fine him for beginning construction without securing a permit, but later these were held over, pending disposition of the greater question arising out of having done a specified act prohibited by the zoning ordinance. After the structure had been completed, and in order to validate his action, the owner applied for a permit. It was refused, and the matter proceeded to the Board of Appeals, as provided for in the ordinance. The Board sustained the Superintendent of the Bureau of Building Inspection and refused to order the issuance of the permit. This case was taken to the Common Pleas Court of Allegheny County and decided June 9, 1924.

The particular section of the ordinance which was violated was the one requiring that:

"When the front wall of eighty per cent. of all of the buildings on one side of the street, between two intersecting streets, have been kept back from the street line, no building hereafter erected or altered shall be placed nearer to the street line than the distance established by the majority of the eighty per cent. at the time of the passage of this ordinance."

Although some of the houses within the block had a lesser depth of front yard than that which obtained when this porch had been enclosed, it was

apparent that, in this particular case, the depth of front yard would not conform to the requirements of this 80% clause. The appellant in this case alleged, as usual, violation of the Constitution of the State and illegality of the ordinance, and particularly that no power existed to prevent the enclosing of the open porch already constructed.

The Court decided that the enclosed porch, as constructed, had been turned into a part of the house, and its construction was prohibited by the ordinance. The Court also decided that the constitutionality of the Enabling Act had been approved by the same Court in the case previously referred to and, further, that:

"The requirements of conformity of depth of front yard to that already put in use by eighty per cent. of the owners was not unreasonable and in fact it would be difficult to imagine what regulation could be made on that subject which would be more favorable to individual owners and at the same time amount to anything as a regulation."

This case has been appealed to the Superior Court of the State of Pennsylvania and will probably be considered after the Supreme Court has decided the former case.

EXPERIENCE WITH ZONING

Additional Problems.—Experience has shown that there are many details of zoning on which additional enlightenment is needed and which should be studied. Perhaps the most important is that of the regulation of the height of buildings. A reasonable recognition that the skyscraper is not alone responsible for all forms of street congestion will go far toward obtaining a wise interpretation of conditions as they are found.

Skyscrapers.—In this country, the location of theaters is not controlled as in London. Consequently, as exhibited in New York, most of the theaters empty their population at one time and within such a small area that the capacity of the few stations on the subway in the vicinity is taxed to the utmost for a half-hour period following the close of the theaters. A further recognition that large department stores, many of them within short distances of each other, materially serve to congest the sidewalk population and even the roadways, to a large extent, and greatly add to the fire hazard, will do much to aid in understanding that the problem is not simple.

In this country the skyscraper has a great appeal, and our large buildings have no equals anywhere else in the world. Whether it is due to a question of personal pride, or a desire to get ahead of the other fellow, or to make a monument for one's name, it must be evident that both private and public money is being wasted. As a prominent real estate authority in Chicago has stated:

"A tall building is responsible for raising ground value above the possibility of its earning power. The skyscraper in Chicago is an economic and financial blunder."

With the accomplishments of New York and the absurdly high limits of Chicago and Pittsburgh of 264 and 265 ft., respectively, the average height

of buildings in Manhattan is only 4.8 stories, and below Canal Street, only 7.8 stories. In Chicago, within the Loop, the average height is about 7 stories. In the business triangle of Pittsburgh, between the two rivers, the average height is 4 stories. It appears, therefore, that even with such liberal possibilities, not every one wishes to be foolish, but many are driven beyond a reasonable performance by the avarice of their neighbors. Public sentiment grows with popular education. As Mr. Veiller has expressed it:

"The private financial interests * * * would do well to give careful heed to whether such comparatively mild limitations on height as are proposed in most of our zoning ordinances, will be enacted, or shall we have in a few years in the United States what they have had in England for many centuries, 'A Law of Ancient Lights', or its equivalent, by which a man who erects that which diminishes in any way the light of his neighbor, will have to pay substantial damages for the impairment that he has wrought to neighboring property. That is the law in England to-day and has been since time immemorial, and because of that law the great City of London is free from the skyscraper."

Single-Family Districts.—One of the mooted questions in zoning to-day is that of prescribing single-family districts in certain sections of the city. It is certain that unless the Enabling Act is quite definite in its statement, it is extremely dangerous to legislate for one-family districts. Even then, it may be better to accomplish this purpose indirectly by such provisions as regulating the number of families per acre or the size of lot per family.

However, there is a growing desire on the part of many that one of the principal functions of zoning is to preserve the homelike character of single-family residential districts in many cities and this does not emanate altogether from the well-to-do. Even the small wage earner likes his little cottage with plenty of land, when he can afford it, and does not enjoy the encroachment of the apartment building or the row house. There are many reasons for this, and much can be said in favor of this extension of the police power to promote the safety, health, morals, and general welfare. There will be fewer delivery wagons, fewer store men and attendants; less noise, dust, and danger to children on the streets; less opportunity for the incipient cause and spread of fire, and many similar reasons which have been recognized in some jurisdiction by Courts of the last resort.

All is not clear, however, and much progress must be made, facts ascertained, and the public and Courts educated, before it can be certain that in all cases there will be a uniform upholding of such restrictions as one-family districts, particularly as compared to the double house and the two-family house.

Front-Yard Depths.—Another subject which has led to much controversy is that of the requirement of the depth of front yard, particularly as relating to the encroachment of porches, covered and uncovered, enclosed and unenclosed. Reference has been made to the White case in Pittsburgh, which is still to be heard in the highest Courts of Pennsylvania. Careful distinction must be made between the requirements of the depth of front yard and the reasons therefor, and the customary and frequently observed regulation of building set-back lines which, in some instances, have been established for an

entirely different purpose than those arising under the zoning law. The speaker refers to the desire to have buildings kept back on opposite sides of streets, so that ultimately a street may be widened without the payment of excessive damages for structures and by the payment only for the land taken. This method of widening streets and serving notice some years ahead of the actual operation has been a common practice in some States.

However, such action must proceed under the authority of eminent domain and when the land is actually taken, compensation must be paid. The preliminary location of the street line is only a warning to the owner not to erect buildings. The regulations of zoning, however, and the provision for a sufficient depth of front yard, or may be the width of side yard at corners, must be sustained under the police power, on the basis of promoting health, safety, and general welfare.

Stability Desired.—Presumably, there will always be some discussion as to that which is fair and reasonable in zoning. In time, stability will be acquired. This may be a slow process and require much education. Something will depend on the temperament of the people in a given locality, and how much they have been hurt in the past by the adverse action of others. One thing is certain, however, popularity is a dangerous thing, and as to zoning there is no exception. It behooves those who are sincerely in earnest, therefore, to go slowly and see that too rapid strides are not made too far in advance of the general public necessity and desires. There has been considerable campaigning among certain selfish interests inimical to the understanding or an intelligent discussion of the subject of zoning, but this is now abating, as a result of quiet but persistent and intelligent discussion of the principles and the need. It is interesting to quote from remarks of the General Solicitor of the Title Guarantee and Trust Company of New York, the following:*

"The highest form of ownership of anything, personal property or land, would be unlimited in duration and unfettered by any limitations upon use; but there is no such thing in any civilized community. All property is liable, in every civilized community, to those limitations upon its use or ownership which the necessities of civilized life impose, as expressed in the law." * * *

"Under police power, the community may restrict the use of property to avoid hurting the life, health, or morals of others. The community may establish and enforce ordinances to provide a certain standard of light and ventilation, to prescribe how buildings may be erected and equipped, and the percentage of ground to be covered. And if these requirements be not observed, the State will circumscribe the owner's dominion over his land. * * * Those who are fighting City Planning, of which Zoning is the cornerstone, seem to labor under the delusion that the owner of land has the absolute title. The above shows very clearly that our rights are limited. And for the sake of the best interests of society they perforce must be limited. * * * So, as a matter of fact, the principle is already established that an inappropriate use of land may be prohibited—therefore, why fight Zoning, which is the most orderly way of obtaining the desired results."

J. C. Nichols, Realtor, of Kansas City, Mo., than whom there has been no more advanced civicist and public spirited real estate man in the country, has put it directly up to his professional brethren when he asks:

* From *Magazine of Building Management*, February, 1924.

"Is your city poorly zoned as to use, height, and bulk of buildings?

"Do you, in your city, permit property values to be stolen by unnecessary encroachment of property of injurious uses?

"Have you carefully studied the proper building heights for your particular city? One tall building in New York to-day casts a shadow at 4 P. M. across 7½ acres of land, taking away the essential sunlight from all the occupants of the buildings within this area.

"There is both a human and commercial limit to the carrying capacity of streets serving the pedestrian and vehicular traffic incidental to such tall buildings. * * *

"Are real estate values stable in your city, or do they shift almost with each decade? Have you blighted residential areas, or abandoned business sections? Is your city building a constant process of building up and tearing down—an extravagant American custom and a gigantic economic loss?"

Walter Stabler, Comptroller of the Metropolitan Life Insurance Company of New York, says that an estimate of \$1 000 000 000 per year is conservative for the losses resulting in American cities as a result of shifting residential and business sections and the economic hazards and property injury resulting from improper encroachment of enterprises of undesirable and conflicting character.

SUMMARY

Much progress has been made in the field of zoning since the City Planning Division of this Society was organized. Popular sentiment, which has been developed by well-intentioned and well-informed publicity, resulting in more thorough education, has had much to do with this.

However, failures are still being recorded. In general, these are due to an incomplete or inadequate zoning enabling act; to the lack of comprehensive and thorough local study; too much haste and lack of publicity and education; partial, piecemeal, temporary, whimsical, or unreasonable regulations; too difficult or too easy provisions for securing amendments; and to the fact that there is no Board of Adjustment, to vary the ordinance in special cases of difficult interpretation.

The whole atmosphere of zoning regulations, their inauguration, preparation, administration, and interpretation should be one of reasonableness and sanity, with no attempt to accomplish a result too far in advance of the general public sentiment. Interpretation of such a drastic instrument should be in a kindly manner, with a firm yet friendly spirit.

Many unsolved questions still remain and many such as the proper restriction on height of buildings and the effect of such on congestion and safety, and the extent to which one should go in prescribing single-family houses and strenuous area restrictions, are matters about which much more information may be expected. In all stages and in all progress, the fact must not be overlooked that zoning is a part of city planning and not a thing separate therefrom. Bacon says:

"He that builds a fair house upon an ill seat, committeth himself to prison. Neither is it an ill seat where there is ill air only, but where there are ill ways, and ill neighbors."

HEIGHT LIMITATIONS IN ZONING

BY JACOB L. CRANE, JR.,* M. AM. SOC. C. E.

The earliest limitations on building height, as far as the writer has been able to determine, were established in Rome under the Emperors Augustus and Trajan. The congestion of population in Rome, as in modern cities, made the high tenement house profitable. Acting under the pressure of complaint against the overcrowding, with its fire hazard, Augustus limited the height of all new buildings to 70 ft., and Trajan established a 60-ft. limitation.[†] The need for regulation and the precedent for it are, therefore, not less than 1500 years old.

In modern times the precedent for height limitation was established in France and Germany, and from there spread to the Swiss, Scandinavian, English, and American cities. In 1882, height regulations were in effect in Paris. In 1891, shortly after he had been employed as Mayor of Frankfort, the famous Franz Adickes introduced a zoning system which incorporated height regulations expressed in terms of the street width.

The London Building Act, which regulates the height of buildings, went into effect in 1894. An unsuccessful attempt was made during 1923 to break down this code and to permit "American building development". The limitations in European cities range from 43 ft. in Zurich to 80 and 82 ft. in London and Vienna, respectively.

In America, the first height limitation was established by the City of Chicago, Ill. In 1892, an ordinance was passed setting 150 ft. as the maximum height, but this ordinance was vetoed by the Mayor. During the following year an ordinance went into effect limiting the height of buildings to 130 ft. After being raised to 260 ft., reduced again to 200 ft., and again raised to 260 ft., the Chicago height regulation has finally been incorporated in a comprehensive zoning ordinance (1923) which sets the limit at 264 ft. on the building line, plus additional height with set-back.

Several other American cities established height limits previous to the era of zoning, as follows: Baltimore, Md., 175 ft.; Boston, Mass., 125 ft.; Erie, Pa., 200 ft.; Los Angeles, Calif., 150 ft.; Milwaukee, Wis., 225 ft.; New Orleans, La., 160 ft.; Portland, Ore., 160 ft.; Washington, D. C., 160 ft.; and Minneapolis, Minn., 185 ft.

In all these larger cities (no less than one hundred in Europe and America), the conditions making height limitations necessary have been much the same. Laws of this kind, limiting the use of private property, have never been enacted easily, and height regulations could not have been passed except with the support of purposes of great public importance. Communities have found it necessary to curb the greed and the disregard for the public interest on the part of property owners. The theory underlying height limitations as important measures for public welfare may be outlined as follows:

* Municipal Development Engr., Chicago, Ill.

[†] The Town Planning Review, London, England.

(a).—Such regulations control the fire hazard, which increases with each additional story, other conditions being the same.

(b).—They tend to limit the congestion on the streets and in public conveyances, the congestion which follows the crowding of people and business in buildings served by the streets and public conveyances.

(c).—They help to preserve the light and air necessary to healthful life in crowded centers.

(d).—They spread business and, consequently, values over a larger area than would be occupied by higher buildings.

(e).—They have a favorable effect upon architecture, tending to produce a uniform cornice height along streets.

The advantages of high buildings which have been urged as arguments against height limitations, are:

(f).—They bring great numbers of people within a small area and thereby make it possible to go quickly and conveniently from home to workshop, or from office to office, to the end of promoting great efficiency in a city's business.

(g).—They make it possible to earn a return on enormous land values, which produce taxes, as do the great buildings themselves.

(h).—They are in themselves clean, healthful buildings, particularly for office purposes.

(i).—They offer opportunity for monumental treatment as an expression of American life, which can only be expressed by the steel frame skyscraper; and these monuments cannot be simply ornamental towers, they must be big enough to "pay."

Based on the theory just outlined, municipal legislative bodies in America have found it to be sound public policy to establish "reasonable" height limitations under the police power which is vested in the States and delegated by them to the cities and villages. Furthermore, the Courts have sustained such applications of the public power in several conclusive cases. The earliest test case was in Boston, *Welch vs. Wasey*, in which the height limitations were upheld by the highest Court in Massachusetts and, later, by the Supreme Court of the United States. A recent and perhaps the most conclusive case is that of the Wisconsin Telephone Company *vs. the State of Wisconsin*, in which the Supreme Court of Wisconsin upheld the height regulations of the Milwaukee zoning ordinance. There seems to be no room for doubt that height regulations reasonably applied are legally sound. The problem before the bodies enacting such regulations is to secure the maximum effectiveness within the limitation of reasonableness in any given circumstances.

In this country, height regulations are now usually established as parts of comprehensive zoning plans which regulate the use of private land, the area which may be occupied, and the height to which buildings may be constructed in districts of different classes. The heights permitted by regulations range from the maximum for office buildings in the central business districts, lesser heights for apartment houses, local business and industrial districts, to the least for districts in which only single-family houses, churches, schools, and accessory uses are permitted.

To attain ideal conditions in the building of a city, the allowable height would differ for different kinds of buildings. Furthermore, ideal regulations for height would vary with the different objectives for which they are intended. These ideal height limitations may be compared with the limitations of American zoning ordinances, in order to determine the relative effectiveness of such ordinances and the possibility for improving them within the range of reasonableness.

Fire Hazard.—Taking the objectives of zoning in the order in which they have just been named, the ideal limitation of the height of buildings to control the fire hazard may be first set down. No frame building should be more than two or two and one-half stories high. To meet this requirement, the building code, which must dovetail with the zoning ordinance for the sake of the effectiveness of both, should establish the character of fire-resistant construction required where buildings more than two and one-half stories in height are allowed. The problem of height limitation, therefore, as regards fire hazard, is that of the so-called fire-proof building. How high can fire-proof buildings be constructed with safety to the occupants? The following is quoted from John Plant, Chief Engineer, Bureau of Fire Prevention and Public Safety, City of Chicago:

"The range of operation of modern fire departments is six or seven stories from the ground. Above this height we are dependent upon inside protection. Many years' experience in the inspection of inside fire-fighting equipment brings out the fact that this interior protection is rarely kept up to fire department ideas as to what this equipment should be.

"The matter of outside protection on window openings, whether this protection be in the shape of metal frame and wire glass windows, rolling steel shutters, or the ordinary iron shutters, or an outside water curtain, has also proven faulty. This is so because metal frame and wire glass windows will resist a temperature of only about 1500° Fahr. Temperatures developed within a burning building usually grow to 2200°, at which heat, brass fuses, brass fused in the Burlington Building fire, and wire glass windows ran like molasses. The question of upkeep of rolling steel shutters, iron shutters, or outside sprinklers, introduces quite a problem because of the fact that these devices are of metal and are in the open atmosphere exposed to the rain and elements. Also, in this particular locality, there is so much soft coal burned, which contains a large amount of sulphur that gives off various corrosive gases which readily attack all metal exposed; thus, in a short time, your exposed metal devices are soon beyond repair.

"It is true that many buildings are equipped with outside iron fire escapes. This, in itself, is a confession that there is danger in the building. A fire escape is useful to an acrobat or a trapeze performer. The average citizen would be helpless descending from the upper floors on our stairway fire escapes. And in the winter time when these stairways are covered with snow and ice, they are positively dangerous. Fire escapes permit greater floor areas without taking out space for interior stairways, and thus are great favorites for increasing the revenue from a given building. In this same line, might also be mentioned the progressive building manager or owner who decides that the interior stairways are being wasted and who cuts off or takes out entirely an interior stairway in order that floor areas may be increased. The problem then of getting that stairway placed back is like asking the gentleman for his right eye.

"Fire escapes in times of fire with window openings directly underneath, as they of necessity must be, are soon put out of service by smoke and fire.

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coming up. It is not unusual for our firemen working on a fire escape to have the fire break out underneath, and large volumes of smoke and fire prevent their coming down the fire escape, making them ascend the fire escape to the roof, where they must find other means of getting down.

"I believe I am safe in saying that nearly all the occupants of an office building do not know where the stairways or fire escapes are. This is so because every day they depend upon the elevators to take them to and from their offices. Should a fire or disaster occur the first thing that goes out of service is the elevator. Now, where are the stairs and elevators? Are they fit to be used or are they, too, out of service because of fire, smoke, or gases, or whatever may be present?

"I do not hesitate to say that had the fire in the Consumers Building, which occurred at 4:10 A. M., on the morning of July 1, 1917, occurred during the hours from 9 A. M. to 5 P. M., Chicago would have seen a holocaust far more horrible than either the Iroquois Theater disaster or the Eastland boat disaster. No one, absolutely no one, and I say this without fear of contradiction, would have left the Consumers Building above the fourth floor, while the fire raged an hour and ten minutes beyond our control. And why beyond our control? Simply because the temperature reached 2200°. Water is used to extinguish fire. Water boils at 212° Fahr. Chemists tell us that along about 1200° or 1400° water is broken into its constituent elements, hydrogen and oxygen, which substances only feed the fire. What is our practice? All we do is try to cool the fire and prevent its spread into adjoining structures. In this particular fire, it crossed a 16-ft. alley and inflicted damages totaling about \$150,000 in the Baltimore Building.

"At the time of fire in a large office building when the body of fire on any floor assumes such proportions that it is leaping out of all the windows, at least five hose streams are necessary on each floor. Take, for example, where the upper eight or nine floors are involved, as was the case in the Burlington Building. This means 40 or 45 hose streams, meaning 4 or 5 fire engine companies in the building. This is nearly half of our total strength in fire engine companies. It takes quite a time to assemble this amount of fire-fighting equipment. In the meantime, the fire is growing, it is not waiting.

"We have had many serious fires in office buildings in Chicago, where the fire originated in the building itself and spread from floor to floor, out through the windows on one floor and 'mushroom', as we say, into the windows on the floors above.

"Fires in fire-proof office buildings are usually very hot, and the blast of heat and unburned gases is always projected horizontally outward from the building. This is so because the floors are usually of concrete or tile and do not permit the hot air and gases to go up through the floor.

"Standpipe equipment in a building is taxed to its utmost to hold a small fire on one floor, because only one or two lines can be taken from the standpipe as only one or two lines are supplying the standpipe from the Siamese connection on the street level."

W. D. Mathews, Chief Engineer, Chicago Board of Fire Underwriters, states:

"In reply to your inquiry regarding the height of buildings that should be permitted in Chicago, I must say that I cannot give you a definite answer without first knowing or assuming certain important conditions, *viz.*, construction, protection, occupancy, exposures.

"If you were to base the height on the ability of the public Fire Department to cope with the fire from the ground, then you should make the limit in Chicago at the present time five stories, or, say, 65 ft.; but if the Fire Department were fully equipped with water towers and apparatus essential for

delivering large streams at high pressure at maximum height, you might build as high as ten stories, or, say, 125 ft."

Sidney J. Williams, Chief Engineer, National Safety Council, writes:

"Aside from the health hazards which have already been discussed, high buildings involve two outstanding dangers to life.

"(a) Possibility of a serious loss of life in an office building fire. The following facts are well known to every one familiar with fire protection:

"1.—Fire-resistant construction will not prevent the contents of a building being completely destroyed by fire originating either outside (as in the Burlington fire) or inside (as in the old Equitable Building fire). There are numerous examples of both kinds.

"2.—This is true even where the combustible contents are no worse than in ordinary office occupancy, as in the two examples cited. Where an office building is eventually used for mercantile purposes, as is often the case, the hazard is much greater.

"3.—Fire-proof enclosure of stair and elevator shaft is very desirable, and often makes these exits usable during a fire, but cannot be depended upon for absolute safety in a high building, because a single door left open, or a small crack, may permit such shafts to become filled with smoke (or fire) rendering them impassable. Also, elevator machinery may be put out of commission by a fire, and it is physically impossible for the average person to walk down twenty or thirty flights of stairs without stopping to rest.

"4.—Outside 'fire escapes' are useful for the Fire Department, but practically valueless as a means of escape on high buildings. The City Fire Department cannot operate effectively from the outside above the eighth floor or thereabouts.

"5.—Inside stand-pipes are often improperly installed, and more often improperly maintained. Many, and probably a majority, of existing installations are of little or no use in an emergency.

"6.—We have not yet had an office building disaster, with the loss of hundreds of lives, simply because the above possibilities have not happened to occur simultaneously in a high building, filled with people. The probability of this combination occurring, with terrible results, is quite as great as was the probability that the particular combination of circumstances would occur, which did occur in the Iroquois Theater, resulting in over 600 fatalities. The most probable occurrence of an office building disaster would be somewhat as follows: Fire starting during office hours, on the eighth or ninth floor, in a room containing considerable combustible material; no one in the room at the moment; adjacent tenants unable to put out fire when they noticed it; fire department summoned late and unable to control fire on arrival, partly because of no effective interior stand-pipes or other protection; elevator and stair shafts unenclosed, or doors on floor where fire started left open or with cracks admitting smoke; perhaps some elevators making a few trips and then jammed with panic-stricken people all trying to get in at once; stairways likewise jammed, if not cut off entirely; firemen able to rescue a few people by carrying them down fire escapes, or from adjoining roofs, until cut off by flames issuing from windows; persons remaining on upper floors then left without any means of escape, with fire spreading more or less rapidly from floor to floor, either through elevator and stair shafts or through outside or court windows.

"7.—Obviously this hazard increases in direct proportion to the height of the building."

These authorities stress the apparent impossibility of enforcing the regulation of building construction and interior protection and of securing adequate fire-fighting equipment to cope with a catastrophe in a building more

than 10 stories high. If it were possible to secure ideal conditions in every other department, fire-proof buildings might be allowed to go to any feasible height. Failing these ideal conditions, as practically every building does, it must be concluded that, on the score of fire hazard, it would be necessary to limit buildings to not more than 10 stories, or 125 ft.

Congestion on Streets and in Public Conveyances.—Congestion of traffic on country roads and on main thoroughfares outside the central districts will not be discussed in this paper. The problem to be considered is that of determining a sound relation between volume of building and width of adjacent street, so that congestion will not result. Subways are an over-costly and unnatural means of transportation, except where conditions have become so aggravated that they are the only solution and in such case the writer believes that the inflated property values and rentals should be the source of the extra cost of subway construction over that of surface or elevated lines. On this assumption the writer will consider that, in or near the business center, the down-town streets should take care of surface cars, of the vehicular traffic having business there (with short-period parking regulations), and of the pedestrian traffic, all without undue danger or inconvenience from crowding.

For study, assume a typical 66-ft. street without car lines, on the theory that such lines have been re-routed to near-by wider, or less crowded, streets. Such a street may be given over to two 15-ft. sidewalks and a 36-ft. pavement. A 15-ft. sidewalk, after deducting for posts, sweeping boxes, and obstruction at show windows and at entrances to buildings, will accommodate two lines of pedestrians in each direction without overcrowding disagreeably. If these pedestrians move at the rate of 3 miles per hour, with a spacing of 9 ft. "center to center", the sidewalk will accommodate the passage of about 3 500 per hour in each direction.

The writer has not sufficient data to calculate with any degree of authenticity the pedestrian traffic produced by high buildings, but estimates can be made which may be illuminating.

If a street of office buildings, such as Upper Wall Street, New York, or La Salle Street, Chicago, is considered, the normal occupancy of such buildings might be at the rate of about six persons to a suite of 600 sq. ft., assuming a reception room with one stenographer and one client, and three private offices, two with one person each and one with two persons, including callers or clients. A building fronting along an entire 300-ft. block, 125 ft. deep, to an alley, with 37 500 sq. ft. gross area and 30 000 sq. ft. net rentable area (after deducting corridors, elevator shafts, etc.), would accommodate 50 such suites, or 300 people on each floor. If 80% of these leave the building between 12 noon and 12:30 p. m., or between 5:00 and 5:30 p. m., each floor will deliver to the sidewalk a volume of pedestrian traffic equivalent to 480 people per hour. If one-half the pedestrian traffic on such a street moves north for three blocks, say, to restaurants, a car line, or a subway entrance, the two north-bound pedestrian lanes on the sidewalks in the block nearest the car line would receive pedestrians at the rate of $\frac{480 \times 3}{2}$, or 720 per hour.

As the convenient capacity of these lanes is estimated at 3 500 people per hour, the sidewalk could comfortably accommodate the pedestrian traffic from buildings, say, 5 stories high, along the street. This assumes that no pedestrian traffic enters this third block from farther south nor from side streets.

It is obvious that this is the roughest kind of speculation, but it seems to indicate that it is senseless to expect 15-ft. sidewalks to carry conveniently the foot traffic from 16 or 20-story buildings. Much further study is necessary in order to reach any rational factor for limiting the height of buildings on this basis, but it is the writer's opinion that if buildings higher than, say, 10 stories are constructed, additional sidewalk space should be provided by arcading the first story to a depth of 3 ft. for each two additional stories. This should be done for each block, and where a sidewalk carries much through pedestrian traffic in addition to that originating in the immediate vicinity, a deeper arcade must be provided.

The pedestrian traffic on streets which are devoted essentially to retail business or shopping rather than office buildings is more a factor of the character and popularity of the business than of the height of the buildings. Large moving picture theatres, "five and ten cent" stores, and bargain stores produce much greater volumes of pedestrian traffic than banks, markets, or stores selling higher priced commodities. With these also, the writer believes it is feasible to determine by exhaustive study, reasonable regulations for requiring arcades or a set-back at the street line, where either the character of the business or the height of the building make it necessary. In every city which has or is likely to have a population of more than 25 000, such regulations would be reasonable on streets in the main business center which are less than 80 or, perhaps, 100 ft. wide. The city plan should determine which streets need this treatment and what the regulation should be. This is not a direct height limitation, but an alternative to accomplish this phase of the purpose of height limitation.

To estimate the volume or height of buildings for which the typical 36-ft. pavement in the 66-ft. street is adequate, is still more complex than the sidewalk problem. Such a pavement will accommodate a line of parked vehicles on each side (parallel parking) and one line of moving vehicles in each direction. In practically every business or office building center of any importance the idea of providing unlimited parking along the curb has necessarily been abandoned. Such parking must be restricted to an hour, or even less, or prohibited altogether. Limiting the height of buildings does not add materially to the carrying capacity of the lanes next to the curb, for these lanes are used for loading and unloading and are not useful for moving vehicles.

The two flowing lanes will carry, at a speed of 15 miles per hour and a spacing of 50 ft., center to center, about 1 500 vehicles per hour in each direction. With traffic officers closing the cross streets on a one to one schedule, the capacity of these lanes, due more to the delay of starting and stopping than to the actual closed time, is reduced to 500 vehicles per hour.

On any important 66-ft. street it would seem fair to assume that half the carrying capacity of the street should be kept free for through traffic not

destined to or from any point on the street itself, and that the other half of the carrying capacity at any given point might be assigned to the service of the buildings along the street for, say, a distance of five blocks. In other words, a traffic rate of 250 cars per hour for all five blocks, or an average of 50 cars per hour per block, would be the service to be expected from this street.

The traffic service demand of buildings is also practically unknown to the writer. Let us speculate as has been done previously in this paper. On the office building street with 50 suites accommodating 6 people each, at any given time, one person might be expected to come or go from each suite each hour. That would mean 50 people per hour coming or going from each floor. It is doubtful whether more than 1 in 20 or 30 of those entering or leaving an office building during business hours come or go by automobile. If 1 in 30 is assumed, the calculation would permit a 30-story office building on the 66-ft. street.

During the hour from 5:00 to 6:00 p. m., however, people leave the buildings at the rate of about 480 people per floor per hour. If 1 in 30 uses an automobile at this hour, there will be 16 cars per floor, or 160 for a 10-story building, which is three times the quota assigned to each block as its share of the traffic, which will tax the street to capacity.

It is evident that these speculations could be turned into genuine calculations by making studies of the various factors entering into the problem for any given actual street or block. The writer believes it is safe to say, however, that any height limit established on the basis of traffic accommodation in the streets could not permit buildings more than 8 or 10 stories high on 66-ft. streets, nor more than 16 stories on 80-ft. streets. Circumstances such as car tracks, moving picture theatres, the necessity for carrying very large volumes of through traffic, or, conversely, the lack of through traffic and a low traffic demand of certain types of buildings, indicate the necessity for studying the problem for every given situation or for every block.

In general, however, the writer believes that limits could be fairly set on the basis outlined, and that any building exceeding those heights should be required to arrange for arcades or set-backs at the street level for the entire block frontage.

Light and Air.—In support of the necessity for light and air in downtown streets and buildings the writer will again quote from "Studies on Building Height Limitations,"* as follows:

"I will talk particularly on the subject of the need of sunlight in relation to colds, coughs, influenza, bronchitis, and pneumonia; and also on the subject of over-crowding on the street cars in relation to the same infections enumerated above.

"First, I want to bring to your attention a series of charts showing the trend of health in Chicago during the last fifty years. Since the best evidence we have as to health is the death rate, these charts show the death rate of the city by years and decades. The first shows an almost incredible improvement. There have been ups and downs, but the unbroken trend has always been sharply downward.

* Prepared for the Chicago Real Estate Board by Dr. W. A. Evans, Health Editor, Chicago Tribune, and formerly Health Commissioner of Chicago.

"When we come to analyze this chart more closely—dividing the year into parts—winter, spring, and summer, autumn, or taking January, February, and March as an indication of conditions in winter, and July, August, and September as an indication of conditions in summer, we discover a remarkable fact:

"First, that the improvement in health in the fifty years has been due to improvement in summer health. Winter health is about as bad as it was fifty years ago—whereas the summer death rate has fallen from a maximum of forty to a minimum of ten.

"When we chart out the monthly distribution of deaths by ten-year averages, we find that in the 1870 decade the summer months, July, August, and September, had the high mortalities, whereas in the 1910 decade, the mortality is about the lowest of the year. On the other hand, the January, February, and March mortality has mounted.

"Analyzing further, we find that there has been great improvement in the health as regards typhoid fever, diarrhea in children, and death of babies under one year of age—types of causes largely responsible for the old time high summer mortality. On the other hand, a study of bronchitis, influenza, and pneumonia, shows that those diseases are far worse than they were in the 1870 decade. The death rate from them is not quite as high as it was in the Nineties, but it is much higher than it was in any decade prior thereto.

"This study proves two truths: First, we have controlled every disease against which we have seriously contended. Examples, typhoid fever and the summer complaints of babies.

"Second, in a half century, in which we have almost wiped out typhoid fever, pneumonia and its closely related maladies have become materially worse.

"In all the list of germ-caused diseases, the only group that is not coming under control, in fact, is not practically under control, is the pneumonia group, the acute respiratory infections.

"We know about what to do, in fact, we have more scientific information than we had as to typhoid fever when we decided to act in a large way against that disease.

"Are we willing to approach the question of the height of buildings from that point of view?

"There are several kinds of efforts that must be made to meet the problem of the acute respiratory diseases. To enumerate:

"A.—Efforts against the disease directly, such as reporting, hospitalizing, intermediate and terminal disinfection, laboratory diagnosis, vaccines, curative sera, epidermologic procedures.

"B.—Efforts to improve vitality, winter sports, vacations, better habits and customs.

"C.—Efforts to improve the environment, ventilation, smoke prevention, street cleaning, prevention of spitting, sunlight and air in streets, zoning limitation of height of buildings.

"The limitation of the height of buildings relates itself to the problems of the acute respiratory diseases by reason of the decrease of sunlight, diffused light, and air circulation on the pavements and the atmosphere between the buildings, and by reason of the interference with light and air inside them, and also by reason of the congestion on the street cars during the peak hours.

"The surface of the pavement and the lower stretches of the atmosphere are being constantly polluted. Sunlight and drying are needed to sterilize it. If it is not so sterilized, we suffer infections, principally of the respiratory tract. The sun is less efficacious in the sterilizing process in the winter, because of the short effective day (7 hours of effective disinfection as against 13 for summer), the more pollution of smoke, dust, and cloud—the sharper angle."

Charles B. Ball, M. Am. Soc. C. E., Chief Sanitary Inspector, Chicago, enumerates the effects of dark and poorly ventilated rooms upon the persons who occupy them, as follows:

"These effects may be classified as:

"1.—Physiological:

- (a) Loss of color;
- (b) Loss of appetite;
- (c) Loss of weight;
- (d) Eye strain and inefficient vision;
- (e) Nervousness.

"2.—Mental Effects:

- (a) Depression of spirits;
- (b) Irritability.

"3.—Moral Effects.

"Perhaps it is not fanciful to inquire whether working in darkness does not affect the spiritual and moral sense. In the Scripture we read (John 3-19) the condemnation of those men who 'loved darkness rather than light because their deeds were evil.' May we not consider the converse true, namely, that the worker in a dark place suffers a distinct lowering of the moral and spiritual sense because of the lack of a natural environment? May it not be true that the irritability which comes to one who feels the supply of light insufficient to convenient working, results in a distinct lowering of moral standards.

"While conclusions of this kind are possibly speculative we may well think about them.

"Conclusions."—It appears from the evidence at hand, though not at present susceptible of direct proof, that if tall buildings exceed in height at the building line more than $1\frac{1}{2}$ times the width of the street on which they abut, such buildings, by reason of proximity to each other, reduce light and ventilation at the street surface and in the rooms which they contain to a marked degree.

"No economic argument based upon considerations of land value, rate of return on investment, and the like, is sufficient to justify the hazard to health and general welfare imposed by the construction and occupation of high office buildings to double or treble the safe height of $1\frac{1}{2}$ times the width of the street."

The writer believes it must be conceded that, under ideal conditions, buildings should be limited in height to the width of the street, or at most one and one-half the width of the street, or for the 80-ft. street, say, 125 ft., or 10 stories.

Spreading the Business Area.—There is some value to a city in spreading the district of highest values over a large area and thus among many owners, as contrasted to a few owners, who tend to control a city's development for the sake of ever increasing the value of their holdings. Furthermore, the argument of the value of extreme concentration for convenience sake is scarcely valid in any but a few exceptional cases. A financial district built up entirely for that use to a height of, say, 10 stories would accommodate, within the compass of a few blocks, all the financial and allied interests of a very large city center. Most business districts are not well specialized. The Chicago Loop District, for example, has a number of 20 and 22-story buildings, but the average height of buildings in the area is only 8 or 9 stories, and a large proportion of the older buildings have not been converted to any of the specialized

uses which find their most advantageous location in the Loop. If this district were entirely occupied by banking, office building, hotel, theater, and retail store uses, for which it is best suited, it could accommodate, under 10 or 12 stories, all the business in these classifications for a city at least twice the present size of Chicago. More or less complete specialization of such an area will give the desired concentration for purposes of convenience in transacting business, without creating any necessity for very tall buildings.

The greater value of spreading out business centers, or even of limiting main centers for the advantage of outlying business districts, lies in the fact that such a tendency toward decentralization of business is likely to lessen the congestion and its corresponding problems, both economic and social. Of course, the design of the transportation system will have more to do with such decentralization than the limitation of building heights.

Architectural Effect.—The writer is among those who a few years ago favored a flat height limitation because of its tendency to produce a uniform sky line, but who have been converted to the possibilities of a sky line such as that being created in New York by the restrictions of the zoning ordinance height regulations. In districts of lesser heights, the desirability of a fairly uniform height along a street is unquestioned, and height limitations justify themselves for this result alone. In the districts of great height, however, that height limitation seems best, from the architectural standpoint, which permits the greatest height but which tends to produce uniformity in the cornice line of the main body of the buildings and, in turn, makes possible a variety of tower and set-back effects. The ultimate result of this type of regulation is not yet evident, but now no great appeal can be made for a low flat height-limit for architectural reasons.

Among the advantages of high buildings as mentioned previously, concentration of business on small areas has been discussed. For the point that the high buildings are sanitary and well lighted in themselves it may simply be said that the 8 or 10-story building can be and now usually is as well constructed and equipped as the 30-story building. In the monumental treatment of buildings, unlimited height is advantageous. Height limitations of the type in effect in New York are still more advantageous.

The rock on which nearly every height limitation project has been wrecked is that high buildings earn returns on very high land values. The owners of business property of high value appreciate the arguments for height limitations, but when such limitations threaten to emperil their valuations, they, like all good business men, balk. Consider how well American height limitations meet the ideal requirements (ideal only in the sense that they are the actual human requirements for sound public policy) and then re-examine this critical matter of the return on high priced land.

It has been found that the question of ideal height limits requires much more study in order to reach sound and rational factors for setting the limits in any block or for any street. Can it be safely said, however, that the considerations of fire hazard, street congestion, light and air, and decentralization of crowded centers, tend toward a reasonable maximum limit of 10 stories

or, say, a volume of ten times the area of a given lot. The heights allowed by various zoning regulations are as follows:

City.	Maximum height district, in feet.
Atlanta, Ga.....	150
Chicago, Ill.....	264
Hoboken, N. J.....	185
Milwaukee, Wis.....	125
Omaha, Nebr.....	175
St. Paul, Minn.....	130
Washington, D. C.....	110
Akron, Ohio.....	136
Newark, N. J.....	150
St. Louis, Mo.....	150
New York, N. Y.....	250

These regulations carry various modifications with respect to towers and additional height with set-back, but with these, the largest cities with zoning ordinances in effect, only three—Milwaukee, St. Paul, and Washington—have regulations which approach the figure which will realize the purposes for which the regulations are intended.

The force behind the high-building tendency in these regulations is largely that of the owners of property on which such buildings may be constructed. Their demands must be met. Until public ownership of land can be realized, or perhaps some single-tax system (and, in fact, the full success of city planning in general cannot be reached until that time), it is reasonable to expect owners to demand the opportunity for a fair return on the market value of the land.

There are, however, certain factors in this phase of the problem which are often overlooked. One factor of great importance is that with a limit so high as to be virtually no limit, as in Chicago with 264 ft., the opportunity to improve property with very high buildings is less than it would be by a lower limit. For example, the central district in Chicago is now built up to an average height of 8 or 9 stories. Streets and transit facilities are already so badly overtaxed that business is being forced from the Loop area. No arrangement or use of the streets on, above, or below the ground, will make it possible to accommodate successfully an average height of more than 12 stories over the whole area. In other words, the owners of property who are able to improve soon with buildings 20 stories high (the present limit), may succeed in earning a return on the "20-story value" of the land. For every property improved to 20 stories, however, some other property will find the business demand so taken up that it can rent only 4 stories, say, and the value of the land will decline accordingly. A 12-story limit in this district besides achieving important public good in relieving traffic congestion, improving public health, etc., would permit the reaping of the full useful value of the area. This value, however, would go to the pockets of all the property owners, several thousand in this case, instead of into the pockets of only those who are able to improve ahead of the others.

Another factor is the decreasing return on buildings above a certain height, which varies with different conditions. Mr. George C. Nimmons has shown the economic fallacy of the very high building. Due to the area occupied by elevator shafts, supporting members and foundation, the actual rate of return normally declines for buildings of more than 20 stories, and the 20-story building has little advantage over that of 12 stories, and none at all if it cannot all be rented, if it is "overbuilt" to any degree.

Assume that the hope for big reward is so strong in every one of the property owners in the central district that they insist on a height limit greater than the public good would dictate, what can be done to improve height regulations?

The suggestions made seem to be worthy of consideration in this connection and as a conclusion to this paper:

First.—Based on intensive studies in each case, buildings seeking to go above a fixed height, say 10 stories, should be required to arrange for a widening of the street by arcades or by setting the buildings back. If necessary, this may be required to be arranged for a whole block before any building is permitted to exceed the fixed limit, as an arcade along the front of one building alone might not be very useful. This, of course, is not a new idea, but it is offered to tie together the matter of high buildings and wider streets and to place the burden for widening the streets where it belongs, namely, on those who profit most by them.

Second.—Any building seeking to go above the fixed limit of, say, 10 stories, should be positively required to put in the most nearly adequate fire protection and exit appliances that it is possible to devise.

Third.—If the streets and the lower floors of buildings are to be made disease-breeding canyons, other means must be devised for controlling the respiratory diseases, eliminating eye strain and nerve strain, living in an unnatural environment cut off from sunlight and fresh air. It is not likely that these means can be devised, but engineers will be searching for them while more high buildings are being constructed and until the evil results become too serious to endure. Then we will begin tearing down and rebuilding our cities. This will be expensive, but by that time we will know better how to build well for human needs.

HOUSING DENSITY REGULATION

BY ROBERT WHITTEN,* Esq.

In a comprehensive plan of zoning, the regulation of the area of the lot with relation to the number of families that may be housed upon it, performs a very important primary function in securing an appropriate distribution of population and, at the same time, serves other important zoning purposes and supplements other zoning regulations.

The use of the family as a unit of density regulation is open to the objection that the size of a family is variable. There are families of all sizes. A single individual keeping house by himself is considered a family, and there may be families of as many as twelve persons. According to census statistics the average family contains from three to five persons. In 1920 the average size of a family in the urban communities of the United States was 4.2 persons. For the 68 cities of more than 100,000, the average family ranged between 3.6 and 4.9 persons. For any considerable residential area, the population density will vary directly with the number of families housed therein. The law of averages will take care of the exceptionally large and of the exceptionally small families. For all practical purposes the human load on the land can be limited effectively by regulating the number of housekeeping units.

There are some difficulties in the rigid enforcement of the area per family requirement. A house or apartment may be subdivided for light housekeeping, and unless structural alterations are made, requiring the issuance of a building permit, the strict letter of the regulations may be violated. The same difficulty is involved in a rigid enforcement of all tenement house regulations. The housing code regulations governing the erection of tenement houses usually apply to all buildings arranged for more than two families. No large proportion of the population of a city will be housed in light housekeeping, makeshift apartments. With minor exceptions the regulation of the construction of complete housekeeping units will effectively control density. Practical experience under family density regulations both in this country and in England proves that the opportunity for occasional evasion does not materially interfere with their effectiveness in regulating density of population.

In some zoning ordinances the area per family requirement is stated in terms of a limitation of the number of families per acre. This, as here used, is precisely the same as requiring a specified number of square feet of lot area per family. Thus, the Paterson, N. J., ordinance provides that in "D" residence zones and in all business and industrial zones: "No dwelling or tenement house shall hereafter be erected or altered to accommodate or make provisions for more than 110 families on any acre of land or more than a proportional number of families on a fractional part of an acre of land." This is the same as a requirement of 396 sq. ft. of lot area per family, but is a rather involved way of expressing it.

* City Planner, Cleveland, Ohio.

The area per family requirements must be fixed of course with reference to the prevailing lot sizes and housing types in each community. The prevailing width and depth of lots are usually even more important than the prevailing housing types. If, as in many cities, the normal lot is 40 by 120 ft., giving an area of 4800 sq. ft., a good unit is provided on which to base the requirements for all the area districts. In the sections most appropriate for single-family houses 4800 sq. ft. of lot area may be required. In those sections where the two-family house is desired, a requirement of 2400 sq. ft. per family will be appropriate. In an area where small apartment houses should be permitted, a requirement of 1200 sq. ft. per family will permit a four-family house on a lot of the same size as that required for a two-family house in the 2400-sq. ft. district, or for a one-family house in a 4800-sq. ft. district. On a proportionately larger lot, an apartment for any number of families could be constructed. In the higher-value sections, in which large high-class apartments would be the appropriate development, a requirement of 600 or 400 sq. ft. per family may be provided. For cities in which the normal lot depth is 100 ft., a scale of 4000, 2000, 1000, and 500 sq. ft. is usually more appropriate than the scale based on the 4800-sq. ft. area. In many cities a variation in any such scale will be required to meet the conditions created by special types of housing or lot sizes.

In any large city there are a few limited areas where the placing of a family density regulation is unwise. This includes, in general, the apartment hotel section. This is a section where location and high land values make the possibility of congested tenement conditions very remote. The apartments, as a rule, will be occupied by small families of adults. There is no problem of finding play space for great numbers of children. The high-class hotel or kitchenette apartment needs no regulation as to family density, provided it is located in a limited high value district where it will not spoil adjacent dwelling-house areas and where there is no danger of the development of congested tenement conditions. Examples of zoning ordinances in which limited apartment-hotel sections are exempt from the general area per family requirement are those of Atlanta, Ga., Indianapolis, Ind., Providence, R. I., and Columbus, Ohio.

In private dwelling sections in suburban areas, where it is desirable to promote or protect a more open type of development on larger lots, 7500 or even 9000 sq. ft. per family may be a proper requirement. In the Indianapolis ordinance, 7500 sq. ft. is required for such an area; in Cranston, R. I., 8000 sq. ft.; and in West Hartford, Conn., 9000 sq. ft. A section of large lots and beautiful homes is always a fruitful field for exploitation by those who see an opportunity for gain by dividing existing lots or crowding more families on the same lot area. The character and charm of the residence section may thereby be destroyed. Unless each builder is required to make a proportionate contribution to the light, air, and open spaces of the neighborhood, there will be a constant trend toward more intensive building.

In jurisdictions where there is doubt as to the legality of zoning regulations establishing single-family, one or two-family, and apartment-house dis-

tricts, the same result in some cases may be secured by a combination of area per family, lot width, yard, and percentage of occupancy regulations. The West Hartford zoning regulations do not exclude two-family houses or apartment houses from any district, but the area per family requirements combined with the lot width and side yard requirements, make apartment houses uneconomic in the areas designed for one or two-family houses.

The area per family requirement should be applied to the business and industrial districts as well as to the residence districts. No greater housing density should be allowed in an industrial district than in an adjacent residential district. Unless this is done there will be a premium placed on the erection of tenements in the industrial areas. Congested slum conditions may thereby be created. In some instances it will be desirable to place an industrial district in the area district requiring the largest lot areas per family. In most cases a requirement of 4,800 sq. ft. per family in a heavy industrial district will be the practical equivalent of the exclusion of dwellings from such district. Although this accomplishes the same purpose as direct exclusion, in securing a segregation of dwellings from industry, it does so in a less rigid way and in a manner less open to legal criticism.

The area per family requirement should be supplemented of course by the usual height, percentage of lot, and yard regulations. Minimum side, rear, and front yards should be required for all buildings erected in residence districts. Height and percentage of lot occupancy regulations are usually desirable. Bulk regulations, however, no matter how carefully drawn, cannot be as effective in regulating density of population as required-lot-area-per-family. There is always a tendency to crowd more families into a given space. Rooms are made smaller and the number of rooms per apartment reduced. Bulk regulations cannot prevent this. Crowded tenement conditions are likely to result.

For a residence section occupied by people of a given racial, social, and economic class, there is a certain normal rent per house or per apartment. Land values are based on the net return from the rentals received from the customary improvement of the lot. In a given district, the land values increase with the number of families normally housed on a lot. The speculative builder sees a large opportunity for gain in crowding more families on a lot than has been customary in the neighborhood. He buys a vacant lot at a value based on its net return from use for a one or two-family house and builds a four-family house, and is usually able to pocket the difference between the cost of a single lot and the cost of two lots. After a considerable number of such small tenements have been erected, and land values have thereby been practically doubled, the same process is repeated. The speculative builder discovers a profit in building six or eight-family tenements on lots of the size originally used for one or two-family houses. This process of a more and more intensive use of the land and a corresponding increase in land values continues until at length slum conditions are produced.

As long as there is a premium on more and more intensive housing, that is the type of housing that will be most largely supplied. This is particularly

true of the cheap rental type of housing. The tenant has to take what is supplied. In a growing city, he is usually required to pay the same or a somewhat higher rent for ever smaller and smaller quarters in an ever more and more congested and undesirable neighborhood.

Under present conditions in limited sections of most large cities there is a concentration of jobs for cheap labor, that furnishes economic if not social justification for crowding in the near-by residence areas. Where such conditions exist, regulations will be practically forced to recognize them. An allowance of one family for each 1 000 sq. ft. of the area of the lot will adequately satisfy this housing demand under most conditions of industrial concentration. It would result in a probable density of 40 000 to 60 000 per sq. mile. This density although undesirable is low as compared with existing densities in New York and existing trends in limited areas in many other cities. Many of the four and five-story tenements now being erected in New York have only 200 sq. ft. of lot area per family. This creates conditions of tenement congestion from four to five times as severe as the suggested minimum requirement of 1 000 sq. ft.

If in a cheap tenement section, as just described, land values are already based on the housing of eight families on a 40 by 100-ft. lot, it is too late to apply the 1 000-sq. ft. requirement. In zoning it is not practical to adopt regulations that will reduce land values generally in any considerable area. The pyramiding of land values and congested housing, however, can be stopped where it is. Family density regulations are necessary to prevent the eight-family from increasing to sixteen and the sixteen to twenty-four.

It is assumed that with the housing density regulations, supplemental zoning regulations and thoroughfare and transportation facilities will be provided, that will bring about a corresponding distribution of business and industry. Concentration of industry in one part of the city tends to a congestion of population in the adjacent sections. Similarly, the congestion of population in any part of the city tends to a concentration of industry in the adjacent sections. The best conditions both for the industries and for the housing of the workers can be obtained where there is a proper balance between the areas devoted to industrial use and the adjacent areas available for housing.

Zoning regulations supplemented by thoroughfare, transit, and transportation planning, can promote the decentralization of business and industry to sub-centers or to suburban or satellite towns. With such appropriate decentralization there is no economic justification for the housing of the mass of the population in tenement houses. Abundant land will be available for housing convenient to the various business and industrial centers.

One fundamental means of traffic relief in the great city is to take from the traffic or business center the industries and businesses that do not properly belong there; and especially all those that can be more economically conducted in sub-centers of business and industry located throughout the city and its suburbs. Ideally, the big city proper should be devoted primarily to commerce and to the homes of the people engaged in such commerce. The

suburban towns and satellite cities clustering about the big commercial city should be devoted chiefly to industries and to the homes of the workers employed in such industries. This arrangement would reduce the traffic, transit, and housing problems to a minimum and increase commercial and industrial efficiency.

The prevention of the increase and spread of tenement congestion in the housing areas near the business center of the great city is one of the ways by which the decentralization of industry can be most effectively promoted. Housing congestion leads to increased industrial concentration and every increase in industrial concentration leads to increased housing congestion. Just which is cause and which is effect is often hard to determine. The one thing that is clear is that congestion breeds congestion. A zoning regulation requiring a specified number of square feet of lot area for each family for which a tenement is arranged, is the most effective remedy yet devised to cope with this congestion problem.

Housing density regulation has played a prominent part in England in applying town plans to the unbuilt areas. The density requirement is usually stated in number of houses per gross acre. The permitted per acre densities range from about four single-family dwellings to a maximum of twenty single-family dwellings. The town plan divides the housing areas into zones with a varying family or building density requirement. The regulation applies to tracts or land units and not, in the first instance, to particular building plots. The owner or subdivider of a land unit may provide for various types of houses and lot sizes as long as the prescribed housing density is not exceeded for the area as a whole, including the area devoted to streets, parks, and open spaces. This power to control family density is one of the most useful and important features of English town-planning practice. It will be equally important in the United States when a way has been found to apply comprehensive planning to unbuilt and unsubdivided areas.

However, density regulations should not be applied to large unsubdivided areas so as to prevent an appropriate variety in housing types and lot sizes. Although the single-family detached house is a favorite type in all American cities, there will be few large residential neighborhoods in which a limited number of two-family houses, group houses, or apartment houses will not be economically and socially desirable. Although Forest Hills Gardens, New York, is an attractive residence suburb, primarily for single-family detached houses, it has small areas for apartment houses, and other limited sections for group houses, all clustered about its carefully designed and controlled community and store center. Zoning should not bar the possibility of such layouts in any large unsubdivided area.

To accomplish this, the area per family requirement in the unbuilt areas should be based on gross areas as applied to each particular subdivision. Thus, a gross area requirement of 8,000 sq. ft. per family would be reduced to a net area requirement of 4,800 sq. ft. if 40% of the gross area were devoted to streets, parkways, or small parks. This would serve the purpose of balancing the actual density of population and the contribution of each owner

of land to the open development of the entire area, and, at the same time, make it easier for the individual subdivider to appreciate the advantage of contributing the street, parkway, and small park areas required under the planning regulations. In a general way, the maximum number of dwellings to be erected on each tract would be fixed and the only question as between the subdivider and the planning authority would be as to how a small portion of the open space required should be divided. Whether the size of the individual house lots should be reduced and the area thus saved used for wider streets and small park reservations; or whether the maximum yard area should be retained in the individual house lots? To encourage more adequate provision of park area, it would probably be desirable to allow a more than proportionate deduction from lot area for area devoted to parks. It might be provided, as in the recent West Hartford zoning ordinance, that area devoted to small parks or parkway strips may be given double value in computing gross area for the purpose of determining the number of families that may be provided for within a subdivision.

In American zoning ordinances the density regulation, whether families per acre or area per family, applies to the net area of the particular lot on which the proposed building is to be placed. As American zoning ordinances are applied for the most part to already built up or subdivided areas, it is essential that the area requirement should relate to each individual lot and building. As in many American cities there are large unsubdivided areas within the city limits and, therefore, controlled by zoning, it is desirable to devise some more elastic means of density control, such as that used under the English Town Planning Act and applied in modified form in the West Hartford zoning ordinance.

The chief purposes of family density regulations may be summarized, as follows:

- 1.—The prevention of the development or spread of areas of excessive tenement house congestion such as those that exist in most large cities and in many smaller ones.
- 2.—An escape from the vicious circle of more intensive housing resulting in higher land values and of such higher land values resulting, in turn, in greater housing congestion.
- 3.—An escape from the vicious circle of congested housing causing a concentration of industry in near-by areas and of such concentration of industry resulting in increased housing congestion.
- 4.—The fixing of the most desirable standards of density for housing development in the unsubdivided areas some years in advance of the time when it may become profitable to a few developers to use lower standards.
- 5.—The grading down of the concentration of the residential population in accordance with economic and social requirements from the high value center or centers outward.
- 6.—The securing of an open, detached-house type of development in appropriate areas.

7.—The indirect control of multi-family house construction by area per family requirements that make the construction of an apartment house or of a two-family house uneconomic in all but very exceptional cases.

8.—The possibility of accurate estimates of future population and densities in the various residence areas as a basis for a more accurate forecasting and planning of future needs for all kinds of utilities and public and municipal facilities and services.

BUILDING LINE ZONING

BY LAWRENCE V. SHERIDAN,* M. AM. SOC. C. E., AND J. CLYDE HOFFMAN,† Esq.

For many years, the establishment of building lines has been a subject of consideration by those who have dealt with the problem of the orderly development of growing cities. This study has been prompted by a desire to promote proper living conditions as well as to provide for the future street requirement of the city by arranging for a uniform distance back from the street line, in front of which buildings should not be erected. The open space adjacent to the street which is so necessary for light, air, and the general well-being in residence sections is thereby secured, and opportunity is afforded for landscape treatment and otherwise adding to the beauty of the home and neighborhood. This has been the real purpose of a building line in most cases where residence districts were involved. Where, however, in the growth of the city, it has become evident that the original width of the street is no longer adequate for the increased traffic, and that it is desirable and necessary to widen the street at a future time, building lines have been established to forestall the erection of buildings over the strip of ground adjacent to the street that may be necessary for the proposed widening.

Most of the cases considered by the Courts in the various States have been of the latter type. It will be seen that the establishment of a building line for such a purpose is the taking of private property for a public use, or at least a partial taking at the time the restriction is placed, to be completed when the street is actually widened.

Building lines for such purposes usually involve property of high value, and in many instances are the cause of litigation. This has resulted in a line of decisions setting forth the doctrine that the establishment of a building line is, in effect, the taking of private property, and to be valid, compensation therefor must be made. The Courts have been reluctant to consider the fixing of the building line as coming under the police power; and the validity of any attempt so to do has been a serious question. Therefore, the usual practice was to establish a building line by the exercise of some form of eminent domain.

In more recent years, since city planning in its present form has been adopted throughout the country, one of the first things to engage the attention of those interested in such work, is the building line. It is necessary properly to plan for the development of new areas, and just as necessary to plan for the making over or reconstructing of the older and built-up parts of the city.

If all such building lines must be established by the expensive method of condemnation, the cost would be too great to permit of it being done uniformly and at a time to forestall the erection of buildings, the removal of which might be required later at great expense to the city. To avoid this difficulty, in new and undeveloped areas, the Board that approves plats and subdivisions

* Landscape Archt.; Consultant on City Planning, Indianapolis, Ind.

† Attorney, Indianapolis City Plan Comm., Indianapolis, Ind.

may be empowered to require the designation of building lines on all lots included within the plat, with a penalty or forfeiture clause included and with the right vested in the city or any lot owner to enforce the penalty or to prevent the violation of the restriction. This is the ideal building line. It is a condition or restriction running with the title to the land, and is established without cost, as the subdivider, in most instances, recognizes the advantage to himself in selling lots with such safeguards to the new owners. Such lines have been established, and serious damage has resulted in some instances. There is a lot in Indianapolis, Ind., occupied by a fine old residence built many years ago, which is now used for offices, and, it is said, at a loss to the owner. This lot is near the section of the city now used almost entirely for office purposes, yet it is subject to a building line established before the house was built and when the neighborhood was entirely residential. It is impossible now to improve it with a business building of the character which would be necessary to bring in an adequate return. The damage, of course, is due to the fact that the building line was established as a permanent restriction on the land. Generally, plats should provide that the building-line restriction shall be in effect for a certain period of years, twenty-five years being a reasonable term in most instances.

The City Plan Commission of Indianapolis requires that building lines be included as parts of all plats which are submitted to it for approval, and all plats must be so approved before they are eligible for record. It has been found that the establishment of such lines tends to increase the value of property because of the protection against unthinking or unscrupulous builders who would build out beyond the line to obtain a special advantage for themselves.

To take care of the conditions which may exist in older and built-up business or semi-business parts of a city, when it is deemed necessary to prepare for future widening of streets, various procedures, in some form or other of condemnation, have been devised, usually providing for the postponement of the payment of damages until a future time fixed, or dependent, on the removal of the existing buildings or the actual taking of the ground. These methods have been more or less satisfactory, but they are carried out at great cost to the city.

The Indianapolis Plan Commission was confronted with this important and perplexing problem. It proceeded on the theory that the establishment of a building line over built-up property where the sole purpose was to prepare for a future widening of the street was in reality a part of such widening, and not such a regulation as would fall within the police-power doctrine—that consequent damages must be paid—and, therefore, not within the province of zoning.

However, following the existing law in Indiana with reference to the payment of damages and the assessment of benefits in condemnation for other purposes, the Commission submitted a bill to the General Assembly in 1923, which was enacted, granting to the Board of Public Works the power to establish building lines by condemnation and the payment of damages therefor, with certain provisions for the postponement of such payment, and also pro-

viding for the assessment of benefits against the property abutting on the streets along which such building line is established. The law also further provides that the benefits so assessed may equal the damages. It will be seen at once that the cost to the city by such procedure is greatly reduced. In one instance, a 75-ft. building line along 2 miles of Meridian Street was established at a total cost of \$5 400. This was for damages to one property in excess of benefits. On all other lots for the entire 2 miles, the benefits and damages were fixed at equal amounts.

Under this law, the right acquired and paid for is merely to prevent the erection of buildings between the building line and the street line. All other rights of ownership remain with the owner until the street is actually widened. The great saving to the city is secured by the reduced cost of the later widening, when it is not necessary to remove expensive improvements. Under this method existing buildings are permitted to stand until the actual widening. New buildings are erected back of the building line. In most instances, owners cheerfully assent to the procedure in order to obtain the advantage accruing to their property by the improvement occasioned by the street widening.

Neither of the types of building lines mentioned comes strictly under the head of "building line zoning", but a reference to the methods therein used, serves well to aid in a clear understanding of the theory of building-line restrictions in zoning ordinances, as well as to offer suggestions as to procedure, etc.

In zoning ordinances, the matter is handled in an entirely different way and with a purpose quite different from the purposes outlined under the condemnation methods. Zoning does not attempt to establish building lines for purposes other than those for which zoning itself is established, that is, for health, safety, or public welfare.

Strictly speaking, therefore, "building line zoning", is not the proper terminology. It would be more apt to say "front yard zoning". In many zoning ordinances the term, "set-back line", is used, but because of the uncertain attitude of the Courts on the question, it is believed to be safer to use the words, "front yards", and as far as possible to adhere to that idea, the same results being obtained as if so-called building lines were established.

Since so-called zoning has been used, and, in fact, long before its use, when the only protection of building was through housing laws, it was recognized that the establishment of side yards in residential areas was a real necessity to safeguard the health, safety, and welfare of the public. From the standpoint of fire protection there is no question but that any measure which would compel owners to provide considerable space between buildings would be of value in event of a conflagration. There are instances in every city where houses are built so closely together that the eaves overlap. A fire in one building is almost certain to be communicated to the neighboring houses. With the great preponderance of frame construction in American cities, it was necessary to secure more effective fire breaks between buildings.

Buildings constructed very close together of course occasion shaded windows. Such houses are unquestionably darkened, damp, and do not contribute to the health of their occupants. Many of the housing laws provide for a side

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yard of 4 ft., meaning 8 ft. between dwellings, and zoning ordinances, following the lead of the housing laws, have strengthened side-yard requirements.

Housing laws and zoning ordinances have usually provided for rear yards for much the same reason as side yards. Such requirements have also aided in reducing the percentages of lots occupied by buildings and have thus reduced congestion in dwelling-house neighborhoods.

The arguments for front yards are based on much the same considerations as those for side and rear yards. By their establishment, more light is obtained in streets; there is less fire hazard when the houses are far apart, and, in addition, a greater measure of safety is added on account of the larger yard areas, allowing spaces for children to play unendangered by street traffic. There is no question but that well defined lines on a street contribute to the happiness and health of all its residents. This contribution is a matter of general welfare.

Many incidental benefits arise from the establishment of such front yards. It prevents an owner from placing his building beyond the other structures and thereby decreasing the value of neighborhood property merely to gain an advantage for himself. This, also, is a matter of public or general welfare.

In many cases the establishment of such front yards aids materially in the widening of streets. It should be borne in mind, however, that street widening should not be one of the fundamental purposes in the establishment of front-yard lines in a zoning ordinance. They are based solely on the considerations of health, safety, or general welfare, and should be sustained because they are a proper exercise of the police power. For this reason it is not customary to establish front-yard lines in other than dwelling-house and apartment-house districts. The same arguments, based on the health, safety, and public welfare, might not apply so well to a business or industrial district, and thereby cause the Courts to look with disfavor on the whole subject.

There has been an effort on the part of some to endeavor, through legislative enactment, to place the establishment of building lines clearly under the police power; and it is quite likely that, with the trend of conditions and the necessity for the remedy, the Courts may uphold such enactments and eventually declare the establishment of a building line for any of the purposes discussed, to be a proper exercise of the police power. Until that time, it will be the wise course to recognize the "front yard" as creating the only building line which should be attempted in a zoning ordinance.

Incidentally, the establishment of front-yard lines contributes to the esthetic value of the city, but as happens frequently in zoning and in efficient city planning, beauty results, not as the first consideration, but as a by-product of intelligent planning.

**THE INFLUENCE OF ZONING
ON THE DESIGN OF PUBLIC UTILITIES**

A SYMPOSIUM

The term "zoning" is often used to mean the regulation of building for particular uses. It may also mean restrictions or regulations which have been adopted by a city or town to regulate certain activities within its boundaries. It is generally used to indicate a form of urban planning.

**THE INFLUENCE OF ZONING ON THE DESIGN OF
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THE RELATION OF ZONING TO THE DESIGN OF DRAINAGE AND SEWERAGE

BY PAUL HANSEN,* M. AM. SOC. C. E.

The relation of zoning to drainage and sewerage is so obvious and direct that little need be said on the subject to convince one that an established zoning system facilitates design and favors economy.

Zoning, which may be assumed to be a product of city planning, if begun in time, may prevent low-lying land, subject to floods or troubled with high ground-water, from being occupied in a way that requires drainage, thus obviating sewers on excessively flat grades and, in many cases, also pumping. Flat grades and pumping result in high costs not only for construction, but also for maintenance and operation. If low-lying areas are permitted to be utilized for dwellings they become as a rule low-grade property areas and, therefore, are unable to bear the heavy assessments required for a proper sewerage and drainage system. As a matter of fact, they rarely are provided with a proper installation, and, if they were, a large part of the cost is likely to be saddled on the community as a whole.

Although utilization of so-called waste and unusable areas should not be the criterion for the location of parks, low-lying areas generally lend themselves well to the development of parks with lagoons, brooks, and other interesting features, and when thus developed afford particularly attractive scenic effects for residence property on the higher ground bordering them.

It is not always practical or desirable to acquire or utilize low-lying areas for parks, but it is generally possible to restrict or zone these areas so as not to multiply the difficulties attendant on poor natural drainage. For example, such areas may be adaptable for use by railroads and heavy industries that can afford to raise the natural levels by means of fills. The wastes from some industries such as steel works and power plants make good filling material. Such utilization does not require extensive sewers and underground drainage and, if it should, the value of the properties is usually ample to stand assessments sufficiently large to provide adequate relief.

Although not always the case, a well conceived zoning plan may prevent prematurely at least, the extension of built-up areas into new drainage areas that cannot readily be drained into the common outlet. Extension of communities into adjoining drainage areas may require separate sewage treatment works, always an undesirable arrangement, especially if such treatment works are small and remote; or it may require costly pumping to deliver the sewage into the main drainage area.

The tendency to spread unreasonably over large areas, leaving numerous vacant lots which are unsightly and an economic waste, is a striking feature of a community without a zoning ordinance. This tendency is more likely to prevail in relatively level areas where the laying out of streets is a com-

* (Pearse, Greeley & Hansen), Chicago, Ill.

paratively simple problem and little or no grading is required. Chicago, Ill., presents a conspicuous example of this tendency.

The vacant-lot evil is brought about usually by the encroachment of stores, apartments, and industries in localities originally developed as single-family residence districts. The result is a decline in land values and a decrease in building operations which may extend over many years.

Meanwhile, sewerage and drainage will have been provided, involving relatively high assessments on property which has failed to achieve the increase in value that might normally be expected, or which may actually have decreased in value.

With zoning, property values become assured, and there is a virtual certainty of continuous and steady development with the temptation for land speculation largely removed until the entire area is fully utilized in the manner, and for the purpose contemplated. Thus, it is highly improbable that there will result the economic waste of idle land loaded down with the carrying charges for sewerage as well as other improvements.

The most direct effect that the engineer realizes in undertaking to design a sewerage system, in a community which has been zoned and which has an effectively administered zoning ordinance, is the relative certainty and economy with which he can adapt the sewers to the service they will be called on to perform. It is also well known that combined sewers and storm-water sewers can rarely if ever be provided with sufficient capacity to remove immediately maximum rainfalls. The perfection of sewer performance must be proportioned to property values. In zoned areas the property values are relatively easy to determine and also relatively stable, so that the engineer has a much more reliable guide to judgment than he has where the future character and, therefore, the future value of the property is uncertain. It is further to be noted that with more extended use of the zoning system, more and better data will become available.

An illustration of the advantage of zoning occurred recently in the speaker's practice at Decatur, Ill. In 1920, Mr. Myron H. West prepared a city plan with which a zoning system was proposed. It then became apparent that an extensive revision of the sewerage system was necessary, and the speaker's firm was called on to design a main drainage system to care for present and future requirements, utilizing the existing sewers as far as practicable. With certain areas designated and assured for certain purposes, it was comparatively easy to determine what allowance to make for such items as percentage of impervious areas, depth of sewers required, and volume of sanitary sewage and liquid industrial wastes. By knowing the general value and character of the property to be drained, it was also possible to form a reliable judgment of the magnitude of the storms to be cared for; in other words, how much it was wise and proper to expend for sewers.

Figs. 1 and 2 show typical blocks in zones of different characters. There is also noted on the diagrams the percentages of pervious and impervious areas and the population per acre. These diagrams present what are believed to be average conditions. They are by no means final, and criticism of them in the light of further experience with zoning practice would be interesting.

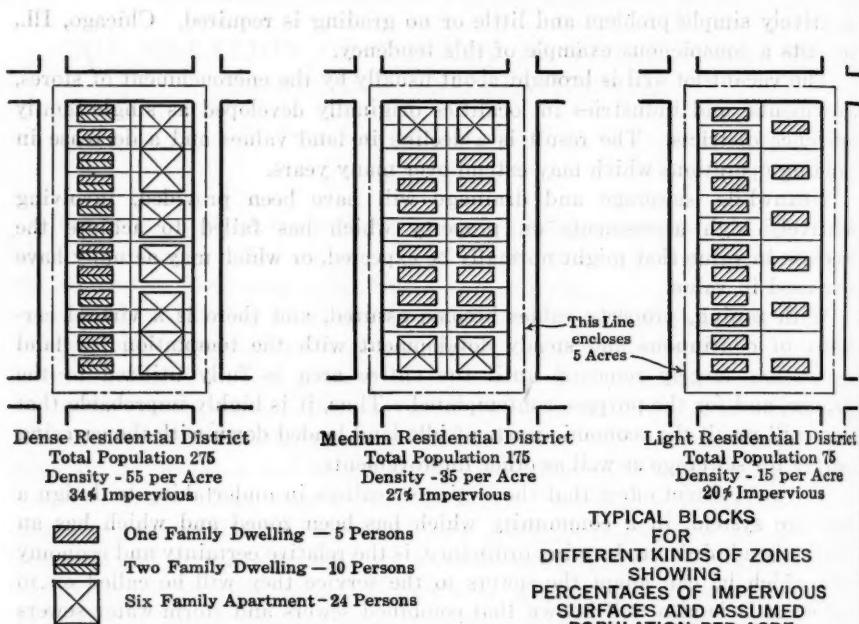


FIG. 1.

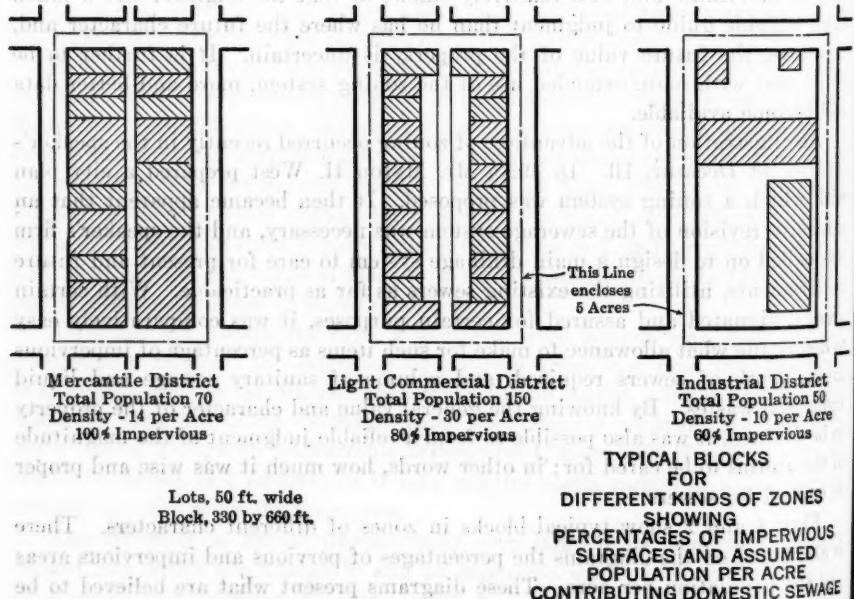


FIG. 2.

The question of the severity of storms to be provided for in designing the sewers within the various zones, a question which reduces to one of how much may advantageously be spent on sewers as insurance against the inconvenience of flooded streets and basements, is difficult to answer. There is no direct or precise way of finding an answer, because it is so difficult to equate the cost against the probable inconvenience and damage. Experience must be relied upon to crystallize practice. This, in fact, is going on at the present time, and practice in the larger cities, while not greatly divergent, is more variable than it should be and is more or less lacking in logical procedure.

Usually an assumption is made that the sewers must be capable of removing promptly a rainfall not likely to occur more often than once in so many years. This method of approach will continue, no doubt, to be the basic method for determining the size of sewers required, and increased experience with zoned areas will greatly improve engineering judgment along this line.

The taxpayer and the municipal official, however, are strongly inclined to consider price, and, therefore, it becomes important that a maximum price per unit of area or per front foot of property must be placed on securing an accepted standard of service. Conditions vary in different localities; a figure per front foot that would easily purchase adequate service in one place, because of good grades and pervious soil, might be inadequate in a locality requiring flat grades and having an impervious soil. Nevertheless, in the larger populated centers, there is not so great a "spread" in conditions, but that figures for the mean price per front foot for complete sewerage may be developed for different zones, which will constitute a fair measure of good and adequate practice. Allowances for departures to the established maximum can be made from these mean figures on the basis of local conditions. Here, again, the wider adoption of zoning will help build up a sound practice that will enable engineers to solve the economic phases of sewer design with greater precision.

In a paper before the Western Society of Engineers, S. A. Greeley,* M. Am. Soc. C. E., has suggested that the front foot cost of sewer service be a measure for establishing what might be called a sewerage policy, and he has assembled costs from various cities mostly applicable to residence areas, because at present these are the only figures available. In general, it was found that, at present costs, the trend is toward \$5 per front foot for complete sewer service. In the future, it will be desirable to study and correlate figures relating to different classes of zones.

From any aspect, the engineer who is concerned with sewerage and drainage can only welcome the wider adoption of zoning ordinances. They mean better sewerage for less money.

* "Notes on the Relation Between the Capacity of Combined and Storm Sewers, Their Cost and the Frontage Assessment", *Journal, Western Society of Engineers*, Vol. 30, January, 1925.

THE INFLUENCE OF ZONING ON THE DESIGN OF THE STREET SYSTEM

By T. GLENN PHILLIPS,* Esq.

Zoning is part of a rather recent and refreshing phase of city planning practice, a phase in which city planners are relaxing rather hopeless efforts to remodel old cities to fit modern needs, and are turning to the more fruitful endeavor of making present-day requirements fit the cities. When the remodeling process has come up against a blank wall—and that is not a mere figure of speech—for further improvement, more intelligent and efficient use of the existing facilities has necessarily been sought. This is true particularly of streets and street traffic. After the utmost has been done in the removal of encroachments and the widening of pavements and there is no way of providing more roadway space except by taking property too costly to take, methods have been devised for handling increased traffic on the existing roadways, often with astonishing and creditable results.

A further step may be taken in continuation of this same process, one which a few far-sighted city planners have dared to suggest, but which to the best of the writer's knowledge no American community has dared to undertake. That step is the control through zoning of the causes of street traffic, the places where people want to go and from which they come, so that no one property or locality will be the point of origin or destination of more traffic than the streets serving it can economically bear.

Zoning has become generally accepted as a logical and reasonable method of controlling the use of property in the interest of the community, but is generally regarded as a device for protecting one property owner against damage from any inimical use to which neighboring property might be put. That zoning may be used with equal reasonableness to protect the streets against action of individual property owners, which may render them less useful to the community, is not so generally realized. Yet, it is only an amplification of the first idea, because if one man so uses his property that he causes traffic congestion which renders the street less useful to his neighbors, or requires an expense for measures of traffic relief not otherwise necessary, he is damaging that neighbor and the community just as surely as if he "hogged" all the light and air or erected a glue factory.

The effective use of city property depends on the use of the streets. If a city lot has no means of approach, it is useless. Its value is measured by its accessibility, and if the effective use of the streets is impaired the value of the property depending on them for access is also injured. When this impairment is due to an excess of traffic over maximum street capacity, there are only two remedies: One is to increase street capacity by multiplying the surface area vertically within street property or horizontally over property previously

* Consultant, City Plan Comm., Detroit, Mich.

devoted to some other use; the other remedy is to restrict the use of property abutting on the streets to the point where the traffic productiveness of each parcel coincides with its share in the traffic capacity of the street. The former is the method generally used where a remedy is attempted, but used alone it is not a remedy—it is simply a postponement. The latter method, however, does provide a real remedy if taken in time, and, if not, may be coupled with the first to make it effective.

It may be well to state before going further that the writer is not using the term "street" in a narrow sense, but broadly to cover all channels by which people or goods proceed from one point to another within a city. This is justified by the fact that the ordinary forms of sub-surface or overhead transit are merely supplements to the street system, and if (as is rarely the case) provided with rights of way independent of street property, are looked on as potential streets whenever traffic demands may cause their taking and proper treatment to provide additional roadway space.

The restriction of the use of property in the interest of advantageous use of the streets may be accomplished under zoning in two ways, first, by limiting the intensity of property use to fit street capacity; and, second, by distributing the kinds of property use to fit the street layout. The first is bulk zoning, the second, use zoning, and, for convenience in discussion, they will be treated separately. Both are applicable over the entire city, but the former has its particular field in the built-up sections where traffic difficulties generally appear first and where the character of the property use is already determined beyond the power of zoning to change materially.

In the down-town sections of large cities, the balance between street property and private property is generally struck well before traffic problems become acute. Property values and types of buildings abutting on principal streets are such that substantial widenings are seldom practicable, and although by-pass routes through back property, along old canal beds, or over railroad rights of way, are often securable, their improvement is costly.

The method of relieving traffic by substituting subways for surface transit has already proved a boomerang, and will continue to do so wherever it is used without rigid zoning restrictions on the height and bulk of buildings in the area affected by the improvement. Every facility for increasing the traffic capacity of a street increases the accessibility of the abutting properties and directly enhances their value. The owners of those properties are seldom slow in taking advantage of the new situation by erecting more commodious buildings which, in their turn, represent enlarged traffic quotas, soon overtaxing the new facilities and demanding still further improvement. As the process goes on, the cost rises disproportionately because the simpler remedies are applied first and the more drastic are deferred, while the costs of necessary property takings and complications in construction are constantly increasing the expense of their realization.

Without the interposition of zoning, the city is powerless to stop the recurrence of these cycles, for its control extends only to the facilities for traffic and not to its causes or results, and even that control is impotent because it is responsive to popular claimor which takes account of little beyond the demands

of the moment. That the cycles bring only increased congestion, less daylight and wholesome air in city life, and an ever heavier financial burden on the public, is sufficient reason for bringing them to a stop.

Zoning embodies the power to do this, but gradually and without the use of the proverbial "monkey wrench". Intelligently applied, it gives notice far enough ahead for the community to adjust itself to the ultimate limit before it is reached. Zoning is based on conditions as they are, it has no power to destroy and build new, but brings improvement by preserving the good and preventing recurrence of the bad. It does not stop growth, but merely directs it along healthy channels.

When the framing of a zoning ordinance is undertaken, the bulk requirements for the down-town sections must be given particularly careful study because of the high property values represented, on the one hand, and because of the vital community interest in adequate approach to and circulation within the district, on the other.

First must come a critical examination of the existing street system in order to determine if it is the best obtainable. There is no advantage in shielding features obviously bad or in preserving deficiencies. Zoning does not correct; its action is preventive. If healthy future growth is assured through its action, it is only logical that any rottenness at the core should be removed before the new growth is added.

There will be situations in which the life of the community has so grown about the defective parts that correction is a major operation. This brings on the next step, an examination of each such case to determine whether the improvement can be made within a cost and with such benefits to the community as to make it economically justifiable. There is often room for nice determination whether the annual charges incurred by the execution of an improvement will not exceed the annual loss arising from its non-execution measuring cost, of course, with due respect to amenities as well as finances. Zoning in itself cannot be relied upon to take care of a bad traffic situation, but in a case where traffic is approaching, but has not exceeded, the capacity of its arteries, the action of zoning may check the process of congestion ahead of the point at which radical measures of relief will be demanded. If the situation has passed the point where, say, the construction of a subway could be avoided, then zoning can be applied on the basis of the subway's existence, but with limitations designed to prevent duplication of the subway facilities at a later date. If a radical change in the traffic capacity of the street system is necessary, either through the opening of new streets or the building of sub-surface transit lines, no zoning limits should be set which will prevent the full economic use of the new facilities, or if property owners are locally assessed for the improvement, deny them the opportunity to recoup the cost by more intensive use of their property.

These studies comprise nothing more than a determination of the best and most economic street system obtainable on the assumption of zoning powers adequate to preserve the relationships between traffic production and traffic facilities on which it is based. Ideally, zoning should come first and the street system be designed to serve the various types of district provided for, but such

action is limited to the undeveloped fringes of cities in practice, and then only to territory within the municipal boundary. With the main framework of the street system established, the province of zoning is to make the best of it, and to prevent such abuse of the facilities by overtaxing their capacity that a re-organization economically disadvantageous to the community will be required.

Once this existing and potential street system is in mind, the framing of the zoning plan to fit it can be undertaken. The relationship between the size of various types of buildings and the traffic for which they are responsible is capable of fairly accurate determination. The number of occupants or daily visitors per unit of floor area can be found by averaging conditions in existing buildings of the same type. The movement of materials to and from the buildings is similarly determinable. The proportion of persons coming by automobile to the door, by transit lines to the immediate vicinity, or on foot from transit line stops or stations at a distance, can also be calculated with fair accuracy, factors being the size of the city, the ease and speed of approach by the different methods, the percentage of car ownership, and future tendencies. A very interesting and thorough study of this kind was made for Cincinnati, Ohio, in 1923, by the Technical Advisory Corporation under the direction of E. P. Goodrich, M. Am. Soc. C. E. On the basis of the usual sidewalk width in the down-town section, the average sidewalk capacity in persons per minute, and the quota of the sidewalk crowd which each office building would have to absorb through its elevator equipment, a figure was computed for the maximum height of buildings permissible if the customary occupants had to walk one, two, or three blocks from the transit lines. The figures obtained, of ten stories on the basis of an average walk of one block, and of only five stories, if that walk were lengthened to three blocks, are sufficient to indicate how far the usual zoning ordinance fails to restrict down-town buildings to street capacity. These figures were based on a 90% utilization of ground area and uniform building to the maximum height. The latter condition is rarely found where tall buildings are permitted, the average for the typical skyscraper district being surprisingly low, but under more drastic restrictions it is probable the maximum would be reached by all new buildings, and that right at least must be accorded all property in the zone under an ordinance presuming to be fair and democratic.

It will be noted that in the study just cited, sidewalk capacity was used as the controlling factor. In down-town office and shopping districts, the bulk of the users approach the buildings on foot, often overflowing the entire pavement area in rush hours. The number of private vehicles using the down-town streets in peak hours is very responsive to traffic conditions, for when the use of the streets is inconvenient, those who use their cars solely for going back and forth to work abandon them in favor of the transit facilities. This leaves the vehicular traffic on the down-town streets composed principally of four elements, trolleys and buses, through travel, necessary commercial traffic, and the cars of shoppers and theatre-goers. The last can be largely discounted, because it comes between the peak hours of the first, except for late shoppers and matinee patrons.

Through travel as found in any one locality, need not be travel passing entirely through the city, but may be traversing one section en route to another. There will generally be proportionally less of this in the central business section than elsewhere, because a larger share of the traffic entering it finds its destination there. The proportion between through traffic and strictly local travel in any district can be determined by traffic counts at the natural gateways to the district, license numbers and time of passage of cars in and out being taken and checked in order to determine how many stay in the area only long enough to effect the passage through it. The thoroughfare system of each city and the location of the various business and industrial areas, freight yards, wharves, etc., will determine how necessary it is for traffic to pass through congested areas en route to points beyond.

If by-passing is possible, it will be used in proportion to the difficulties of direct passage. Where, however, by-passing is not provided for in the street system or is not necessary because of adequate thoroughfares in the down-town sections, through travel will have to be included in calculating street capacity. This rule does not work both ways, for obviously a street with capacity for no more than the through travel using it, could not be restricted to buildings of zero height, but, on the other hand, buildings on an extra capacious street cannot claim greater height allowance if the extra capacity of the street is best devoted to thoroughfare use. Where through travel occupies the greater part of a street at the expense of the local traffic and there is no other route feasible for it, accommodation of the local traffic by special means should be charged against the community. Certainly the abutting properties should not be penalized for the existence of traffic they have no part in creating.

There is a further point worth noting in relation to traffic in the down-town sections. One is accustomed to thinking in terms of intensively developed business sections which tend to draw traffic from all sides to a vortex where trouble is almost inevitable. When the interurban highways also pass through this point, as they generally do, the heightening of the trouble due to the through traffic is very noticeable. Under the operation of a really restrictive zoning ordinance, however, this peak of down-town development would necessarily be flattened out, more territory being covered and hence served by more streets. The accompanying decentralization of traffic destined for the district would automatically relieve the worst situations.

It is obvious that such studies as those just suggested might produce many different figures for allowable height in different parts of a single district. The final step in setting bulk limitations is the averaging of the conditions so as to obtain uniformity of requirements within each zone classification. The width of the street, frequently used as the basis for building height limitations to preserve a given angle of light, is not an equally good basis for limitations in respect to traffic. A wide street might be largely devoted to through traffic with which the abutting buildings have no direct concern, a narrow street might be served by a subway line giving it a capacity for local traffic much greater than that of a larger street without the subway, and so on. Where pedestrian traffic is an important factor, the distribution of transit lines

counts for more than the street width. An absolute height limitation for the district is better from the traffic standpoint, therefore, than a multiple of street width, and except in the case of a very regular street layout, this absolute figure would have to be obtained by an intelligent averaging of the figures computed for different streets and blocks.

Although the question of bulk limitation principally concerns business sections of cities where the greatest number of traffic problems arise, similar considerations apply to other sections. Wholesaling and warehousing areas develop a heavy street traffic which bears a fairly definite relationship to the size of the buildings involved. Apartment house districts create quotas of traffic, both automobile and pedestrian, which are directly proportional to the size of the apartments. The more open residence districts form the principal exception, as the use requirements automatically restrict bulk at a point where traffic considerations do not come into play.

Thus far, the restrictions imposed by zoning on building heights and area have been discussed in relation to their influence on the streets in the immediate vicinity of the buildings regulated. There is a broader effect applying generally over the whole city, which is so closely associated with the effects of use zoning that it can most conveniently be treated under that head. Actually, of course, the use and bulk provisions of zoning ordinances are not independent of one another, for they both apply to the same properties and are designed for the same purpose, that is, to promote orderly and convenient urban growth. The arbitrary separation of the two subjects in this paper was made merely for convenience in treatment.

City traffic is made up of units traveling from point to point within the city, between points outside and those within, or between outside points the connecting route of which lies through the city. The number of these units originating in any given locality depends on the nature and intensity of human activities in that locality, the direction in which they want to go from their point of origin is governed by the nature and distribution of the activities serving as destination, and the total number of units going in any one direction depends again on both the nature and the intensity of the activities toward which that direction leads.

The thoroughfare system is supposed to connect the various localities of a city with one another and with outside points as directly as possible and over connecting links in each case ample for the traffic wishing to use them. The minor streets are supposed to collect or distribute to their individual destinations within the various localities all the units of traffic using the thoroughfares. The more nearly a street system does this with expedition and convenience, the more nearly perfect it is. The more nearly the number and desired routings of the units of urban travel can be calculated in advance, the more perfect a street system can be designed to serve them. Intelligent zoning provides a definite basis for just such calculations. By designating the kinds of activities permissible in various parts of the city, it controls what might be called the "impetus" for traffic between them. Different kinds of activities produce different kinds of traffic, as well as different amounts. Zoning classifies the various localities or districts according to the activities to

be conducted in them, basing their designation on dominant present-day use, natural fitness, or the needs of the future community. It then fixes the classification so that an inharmonious use may not be made of part of a district to the detriment of the activities properly conducted in it. In so doing it fixes the basis for traffic calculations on the assumption of definite localities ultimately occupied by definite types of activity, the traffic requirements of which are known.

Many different kinds and sizes of traffic streams are in daily progress between different localities, but one type is sufficient for an example. Those traffic streams conducting the inhabitants from their homes to their places of work and back again are the most important with which large cities have to deal. Stated in terms of districts, these streams connect residence with industrial and residence with business. If all the business and industry is in one central area and the residential section occupies its periphery, the streams converge; if business is at the center, residence next, and industry in an outer circle, the flow of traffic is much more diversified, the converging streams being smaller because of the movement of industrial workers outward and less exclusively one-way because of the workers traversing the city to reach their destination.

Assuming the first example to be an unzoned community with a thoroughfare system suited to its highly centralized life, the location of a few prosperous industries on cheap land at the outskirts might alter the entire situation, congesting minor streets previously unused and robbing the widest thoroughfares of their excuse for existence. The community, without having a hand in the shaping of the new condition, is nevertheless expected to pay for the widening and cutting of streets through the area of newly created values tributary to the factories, and to carry the potential loss of wide streets elsewhere not used to economic advantage.

The traffic requirements of an acre of industrial plant are not those of an acre of private residences. The latter may hold six or eight families, not more than 25% of whom are ever likely to leave the premises at one time, and can be amply served by a 10-ft. lane. The industrial plant may employ three shifts of 500 men each, arriving and leaving at as nearly the same moment as possible, requiring space for trolleys and buses, and several hundred automobiles, in addition to such trucking as may appear at the same time. It is only fair that the community should know which of these conditions it must contend with in a given locality. Industrial districts particularly are likely to create peculiar traffic problems because of the tendency of individual plants to have only one or two entrances to the premises. Several thousand operatives employed over twenty or thirty acres may all be bunched at one point at starting and quitting time. Even if plant organization does not require this, plant layout, with its surrounding belt of storage yards, coal bunkers, and railroad tracks, often leaves room for little else.

When a zone plan is being considered in relation to the thoroughfare system of the entire community, there is much more room for interplay between the two than is the case with the down-town streets alone. The conditions are not so fixed and the existing street system need not be finally accepted as a deter-

mining factor in the zoning plan. If an outlying section platted for sparse residential use is adapted for industry, there is little to hinder the street changes needed to serve that use; or if it is decided to throw a mixed district wholly into an industrial or a residential class, adjustment of the street system accordingly should involve little difficulty, a residential classification probably requiring no change and an industrial district being able to stand the cost without unfairness or hardship.

The map of use districts, therefore, can be blocked out on the basis of more relevant and vital factors than the street system which happens to exist, and a renovated thoroughfare system established on the basis of the tentative zone map. The framing of the thoroughfare and transit system is then a fairly simple and logical process. The districts in which people live and in which they work are set down in definite localities and with definite boundaries. The ultimate number per acre of those who can live or work in the several districts under the provisions of the zoning act is computable. The potential routes for travel show on the city map, or, better, on the zoning data maps if well prepared. Analysis of the kinds and amounts of traffic likely to use the various routes will determine their adequacy; if found to be inadequate, the possibilities of widenings and the opening of relieving routes can be given the same analytical study.

Transit lines may be located in much the same way, and rapid transit routes fitted into a scheme of surface feeders. The Detroit Rapid Transit Commission has announced its unwillingness to decide on rapid transit routes and facilities until the communities to be served are zoned.

Some leeway may even be found to shift zone boundaries to throw needed traffic arteries away from congested points, and this possibility illustrates the need of simultaneous street and zone system study. When lateral expansion of the down-town district is required because of the impossibility of further vertical expansion without drastic street changes, it is logical and justifiable to direct that expansion where a good street system exists or can most easily be provided.

It is even within the power of the zoner to encourage decentralization of city activities in the interest, among other things, of better traffic conditions. The spread of the business district necessitated by height restriction can be used to encourage satellite business sections strategically placed, and the assured character of the surrounding neighborhood under zoning will aid in their establishment and growth.

To sum up, zoning helps the traffic situation by showing where people are going to live and how many are going to live there, and where people work and how many are going to work there. If a section of the street system is already well established through the development of the surrounding district, the further growth of the area dependent on those streets is checked before reaching the point where they must fail to function. In places where expansion or change in the street system is possible, zoning provides the basis for determining the extent and nature of the changes needed. The chaotic growth characteristic of American cities largely nullifies city-planning efforts. Zoning by marshalling the factors of growth under an orderly control, makes scientific city planning possible and worth while.

THE INFLUENCE OF ZONING ON THE DESIGN OF A TELEPHONE PLANT

By ALBERT P. ALLEN,* Esq.

In many ways a better title for this paper would be "The Design of the Telephone Plant and Its Effect upon the Preparation of Zoning Ordinances". In suggesting this reversal of the title, it must not be assumed that the telephone interests are in any way antagonistic to the plan (which has met with so much favor in recent years) of systematic zoning of large cities in order that their future growth may be controlled and regulated along lines which contemplate, and undoubtedly will secure, the best results for the citizens as a whole. The telephone company, necessarily, is a part of the city in which it operates and is dependent on that city's successful growth. Therefore, anything which is for the ultimate benefit of the city must be of benefit to the telephone company.

In addition, however, to this general interest which the telephone company takes in common with other good citizens, it has a second and even stronger reason for being favorable to the establishment and maintenance of a good zoning ordinance in each city. Such ordinances tend to stabilize and make more dependable the development in the various sections of a city, and, therefore, tend to make easier and more reliable its estimates of future growth and plant requirements in such sections.

Therefore, the real reason, the proposed reversal of title might be considered an improvement, from the point of view of the telephone company, is merely that the design of the telephone plant in any city is almost wholly controlled by the service demands of the public; and unless the zoning ordinance (and, incidentally, all other ordinances) enforced in any city, is drawn in accord with those service demands, any changes in the design of the telephone plant which are caused by such ordinances, although opposed to the facts of the business, can be shown to be harmful rather than beneficial to the public as a whole.

The true interrelationship between the zoning of cities and the carrying on of the telephone business within them can be understood only by those who not only appreciate the real relationship of the present-day public service corporation to the public it serves, but also understand how and why a modern telephone plant is built as it is. These questions are both large subjects, and, in this short paper, the writer can do little more than call attention to some of the basic facts, without going very deeply into the supporting arguments and explanations regarding them.

The first important fact is that the telephone company, being publicly regulated as to the rates it may charge, can have no selfish or mercenary motive in either supporting, opposing, or criticizing any given zoning law or regulation. Its position necessarily is a neutral and professional one, of

* Commercial Engr., Illinois Bell Telephone Co., Chicago, Ill.

interest in efficiency and economy for the ultimate benefit of its patrons, the public. It is not the stockholders, but the customers, of a telephone company who should be most interested that no unnecessary costs of providing service are imposed on the company, because it is they, and not the stockholders or employees, who suffer from, and have to pay for, such costs. This is the first point which must be appreciated by those who have the duty, or privilege, of establishing zoning, as well as all other, regulations affecting the utility services.

The second important fact affecting telephone companies is that the proper and economical plan on which they must build is controlled within rather narrow lines by their customers and by the facts of the business, and not merely, as one might assume, by the whims or theories of their engineers. Each central office or exchange building has to meet several rigid conditions, all controlled by the present and future number and distribution of the customers to be served therefrom, as follows:

1.—It must be within economical transmission distance of all the subscribers it serves.

2.—It must serve the total number of subscribers to be located within such economical radial distance.

3.—Each subscriber must be directly connected by a pair of wires (on an individual or party-line basis) with the switchboard at such a central office.

4.—All such central-office switchboards in a city must be interconnected, by suitable inter-office trunks, for direct and instantaneous connection on local calls, and for prompt connection to all toll or "long distance" points outside that city or exchange area.

5.—Each central office must be located at the economical "wire center" (or telephonic "center of gravity,") of the area it serves, with due allowance for the effect of the trunk circuits and cables on the final determination of such economical centers of distribution.

6.—In small cities, which can be served by a single wire center and office, the center often falls in or near the business district.

In large multi-office exchanges, however, many sub-areas serve residence stations almost exclusively. Moreover, the densest development often occurs in the better neighborhoods, in which case the economical wire center may be determined as lying well within some highly restricted zone.

7.—To move a central office far from its natural economical wire center adds greatly to the investment in conduit and cables and to the corresponding costs of giving service, since, as previously stated, all subscribers' lines must be carried into the central office.

8.—Telephone central offices should be located in clean, quiet neighborhoods, free from the noise, smoke, and dirt of steam railroads, street cars, or heavy street traffic.

It will be noticed that all the eight conditions mentioned have to do with the location or size of the telephone central office, and that none of them has to do with the other features of the design of the physical plant. Such features as the use of underground or aerial construction, system of distributing wires

to reach the premises of individual subscribers, type of switchboard, and other matters which are usually thought of in connection with a telephone plant, are in no way controlled by the regulations of a zoning ordinance. Therefore, it may be said, in general, that this discussion involves only the location and size of central office buildings which are called for by an efficient and economical design of the telephone plant as a whole. Obviously, such a design must be interfered with as little as possible by the conditions of a zoning ordinance if the telephone service is to be rendered in the most economical manner and at the lowest possible rates.

Moreover, the telephone company would not raise these points if their effect on the cost of service was not known to be great enough to be a controlling factor in the determination of necessary rates for service; and, especially, if the differences in cost would be eliminated, instead of being accentuated, by growth, as time goes on. In several cases, if the zoning ordinances had been passed as originally drawn, and had not been changed at the suggestion of the telephone company, the cost of telephone buildings and cable plant would have been greatly increased.

The various conditions which have been listed as controlling the proper location and size of telephone central offices, will now be discussed a little more in detail. These conditions should be recognized as important and necessary in the zoning ordinance itself, and by any Board of Appeals which may be created under such an ordinance.

1.—*A Central Office Must Be Within Economical Transmission Distance of All the Subscribers It Serves.*—By "transmission distance" is meant the combination of length of circuit and size of conductors which apply to the lines of the various subscribers served by any one central office. Although it is true that the state of the art to-day will enable telephone engineers to produce proper telephone transmission over almost any length of circuit, nevertheless, it is obvious that there is a practical distance from the central office battery supply beyond which it is uneconomical to attempt to serve subscribers in any exchange, due to the constantly increasing quantities of copper that would be needed, or the reactions on transmission that would result, if those large quantities are not provided.

There is no uniform or fixed maximum distance which is applied even to common battery subscribers, because the cost varies with the number of circuits in a cable as well as with the length and size of the conductor used to supply any given section. Moreover, the strict maintenance of an inflexible maximum distance would create uneconomical fractional office areas in any large city. For all practical purposes, however, this first condition means that the distance which any subscriber can be located from the central office is quite limited, and this condition creates the necessity for a large number of central office buildings throughout any large metropolitan area. Moreover, it means that the location and size of the various areas are fixed by the service demands of subscribers and not in any arbitrary way by the telephone company.

2.—*A Central Office Must Serve the Total Number of Subscribers to Be Located Within Its Economic Radial Distance.*—This condition will probably

be recognized by all engineers as a necessary corollary to Condition 1. It forms the basis for the economic necessity for the ultimate size and height of the telephone building which must be permitted.

3.—Each Subscriber Must Be Directly Connected with the Switchboard Located at Such a Central Office.—This also states one of the obvious conditions of modern telephone service, and it affects both the location and the size of the central office building, when considered in connection with Condition 4. It illustrates the particular feature which perhaps chiefly distinguishes the distribution of telephone service, if that term can be used, from the distribution of other utility services, either transportation, electric light, electric power, gas, or water, the difference being that each telephone subscriber has to have his own individual connection with the source of service supply, whereas all other utilities serve their customers by common mains, or facilities used in common by large groups of patrons. However, they, too, have important problems to be considered in connection with zoning.

4.—All Central Office Switchboards Must Be Interconnected by Suitable Inter-Office Trunks. The reason for this condition is that all central office switchboards must be available for complete inter-office local service; and also, of course, that they be made available for toll service throughout the telephone system. Thus, a subscriber in Detroit, Mich., has his own connection to his local switchboard, and by means of a trunk to "long distance," a toll line to New York, N. Y., a trunk from the toll-board in New York to a local central office there, and connection with the circuit connecting a New York subscriber with that central office, he can converse with the subscriber in New York with a minimum possibility of interference from any other subscriber. All parts of such a system of interstate telephone connection are so balanced in regard to transmission standards as to give the greatest economy of plant costs for the combined system as a whole.

The exact method of obtaining this balance of transmission requirements between the various parts of the system is quite technical, and would require a extended paper for its complete explanation. For the purposes of this discussion, therefore, it must be taken for granted that the economical balance between these factors has been fairly well determined, and that any conditions arbitrarily imposed on the telephone company, which would upset that balance, would be very unfortunate to the users of telephone service because of the increased costs which would result therefrom.

5.—Each Central Office Must Be Located at the Wire Center of the Area It Serves.—The wire center, or location of the central office, is the telephonic center of gravity of that part of the city which it serves. Obviously, it is not always, if ever, the exact geographic center of that area, being moved away from such a center by a preponderance of either subscribers' circuits, or more expensive but fewer trunk circuits lying in one direction as compared with the opposite direction. It is a center, therefore, which is determined by a study of the present and ultimate number and distribution of subscribers. The actual location of the central office building cannot be moved far from the theoretical center without a large increase in the cost of service.

The extra cost due to such a move of the actual from the theoretical wire center is especially costly in the case of a central office which has already been planned; which will be put into service in a few years; and which, therefore, has had its effect on the underground conduit, pole line, and cable work already completed in accordance with such fundamental plan.

In the same way it would be very expensive to change the ultimate capacity of a building already in service by preventing, through a zoning ordinance, for instance, the completion of the building to its contemplated height or size, thus making it impossible to fulfill Condition 2, which specified that it must serve the total number of subscribers located within the proper radial distance from it. The only alternative, as can easily be seen, is to create an additional, uneconomical, inefficient, and costly central office to serve those subscribers thus ruled out of their natural wire center.

6.—*In Large Multi-Office Exchanges Many Sub-Areas Serve Residence Stations Almost Exclusively.*—This fact makes it impossible, without prohibitive cost, for the telephone company to serve residential areas without placing some telephone offices within and near the center of such areas. The telephone company much prefers a location which is acceptable rather than objectionable to the residents in the immediate neighborhood. It can be trusted, therefore, to select locations satisfactory to the public whenever this is possible without adding too greatly to the total cost of the service. Moreover, the Bell System and, the speaker believes, practically all telephone companies, have made it a practice for a great many years to employ the best architects and to construct a type of building for use in residential areas which is attractive in itself and which conforms as fully as possible to the surroundings in which it is to be placed. In many instances, as a matter of fact, a telephone building is an admitted benefit to the neighborhood, and, architecturally, is as unobjectionable as a public library, a school, or an art museum which are often located in residential sections.

7.—*To Move a Central Office Far from Its Natural Wire Center Adds Greatly to the Investment in Conduit and Cables.*—The reasons for this increased cost have been clearly indicated; and in any instance which might arise under a zoning ordinance, the local engineers could calculate closely just what the expense of any proposed change in plans would mean, both at the present time and ten or fifteen years hence, which is often more important. The calculations would show that any move of a central office from its natural wire center will add greatly to the investment in conduit and cable.

8.—*Telephone Central Offices Should Be Kept as Free as Possible from the Dirt and Smoke of Steam Railroads, Street Cars, or Heavy Traffic.*—Dirt and smoke are always objectionable to an operating force, and are also particularly harmful to the delicate apparatus in the central office equipment of a telephone company. Noise is also objectionable in an operating room, and even the operators are taught to speak in low tones in order not to disturb adjacent operators and not to create an air of confusion in the operating room. With the introduction of machine-switching service, the objection to smoke and dirt is somewhat increased; but even then the objection to noise remains, because

the human element is never eliminated from the central office, even when most of the regular connections are completed by machinery.

Therefore, any provision of zoning which would assume that a telephone office might just as well, if not more logically, be located on a business street or in a district reserved for ordinary industrial uses, rather than on a quiet residential street, involves objections to such a procedure over and above the direct cost which it might add to the giving of service.

In addition to the statements just given a few points will be mentioned, that should be kept in mind when a zoning ordinance is being drafted. They are offered for the protection of the telephone subscribers against unreasonable and unnecessary additional costs for service, which will result if they are overlooked.

1.—The ordinance should permit the erection of telephone buildings in any use district, in order that they may be located at the wire centers.

2.—The ordinance should permit the erection of telephone buildings to economical heights. For example, if the height limit in residential districts would not permit of an economically designed building, provision should be made whereby exemption could be obtained to permit the erection of the building to a satisfactory height. In this connection, it must be remembered that each floor of a modern telephone building requires about 13 ft. of height.

3.—The ordinance should also permit a reasonable use of the plot on which the building is to be located. Some ordinances restrict to a very low percentage, in certain areas, the area of lot which may be occupied by the building. This may constitute an unnecessary and unreasonable restriction if all the facts about the erection of the usual telephone building are considered.

4.—Provision should be made to permit the completion of buildings constructed prior to the adoption of an ordinance to less than the height or bulk to which they were originally designed. This is an extremely important provision; and certainly no objection should be made to the completion of a telephone building along the lines originally planned, in order to give efficient and economical service to the subscribers.

5.—Some ordinances contain a provision that a building may not be occupied in any part for any purpose until the building is entirely completed. This might be a serious restriction on many desirable activities, and it is important that the ordinance provides for a temporary certificate of partial occupancy in advance of the final completion of a building.

6.—A Board of Appeals should be created to hear appeals from the decision of the administrative officer. In other words, there should be a body to which the telephone company may go for relief in case the strict terms of the ordinance would impose an unnecessary or unjust handicap on the telephone service. The experience of zoning experts indicates that a Board of Appeals is most necessary in order that the ordinance may be reasonably applied so as best to promote the public welfare.

7.—It is most important that suitable State enabling acts be in force, which make mandatory certain provisions in zoning ordinances enacted under it, compelling proper treatment in any case in connection with which, from the viewpoint of public convenience or welfare, reasonable necessity for any

ILLINOIS BELL TELEPHONE COMPANY.

CHICAGO EXCHANGE OFFICE AREAS

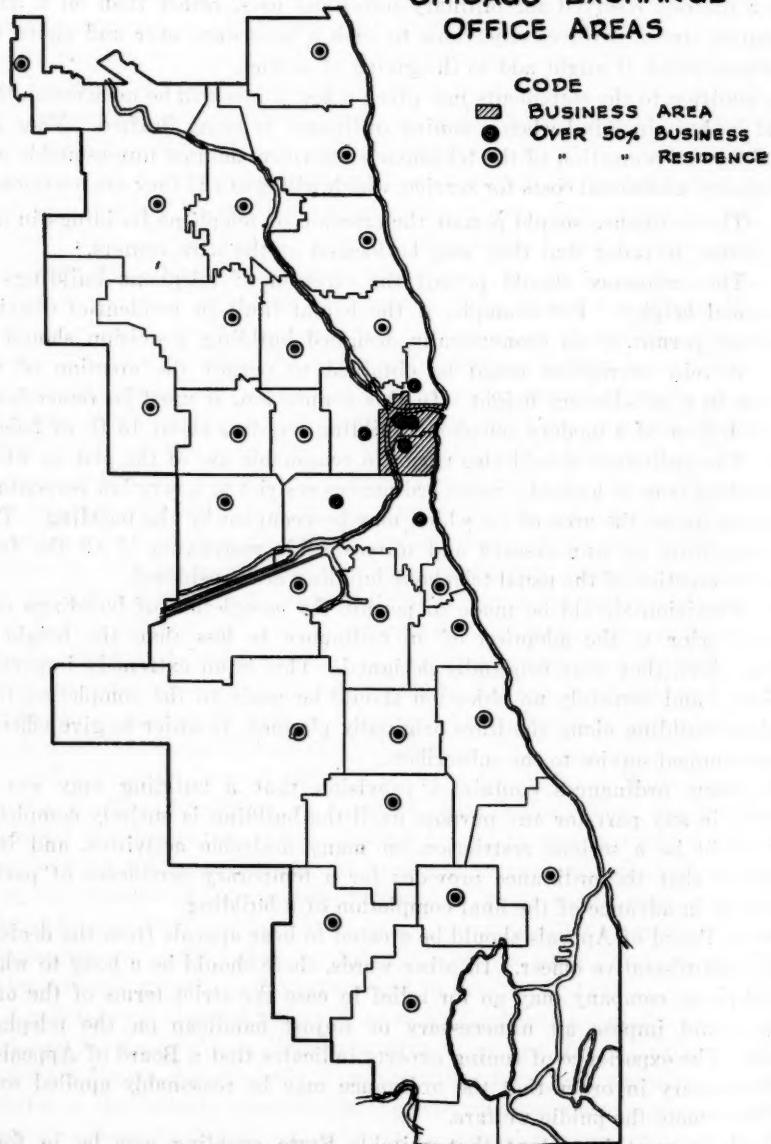


FIG. 3.

ILLINOIS BELL TELEPHONE CO.

COMMERCIAL SURVEY
OF
CHICAGO AND VICINITYMAP SHOWING
DISTRIBUTION OF FAMILIES
IN 1920

1 SPOT-100 FAMILIES

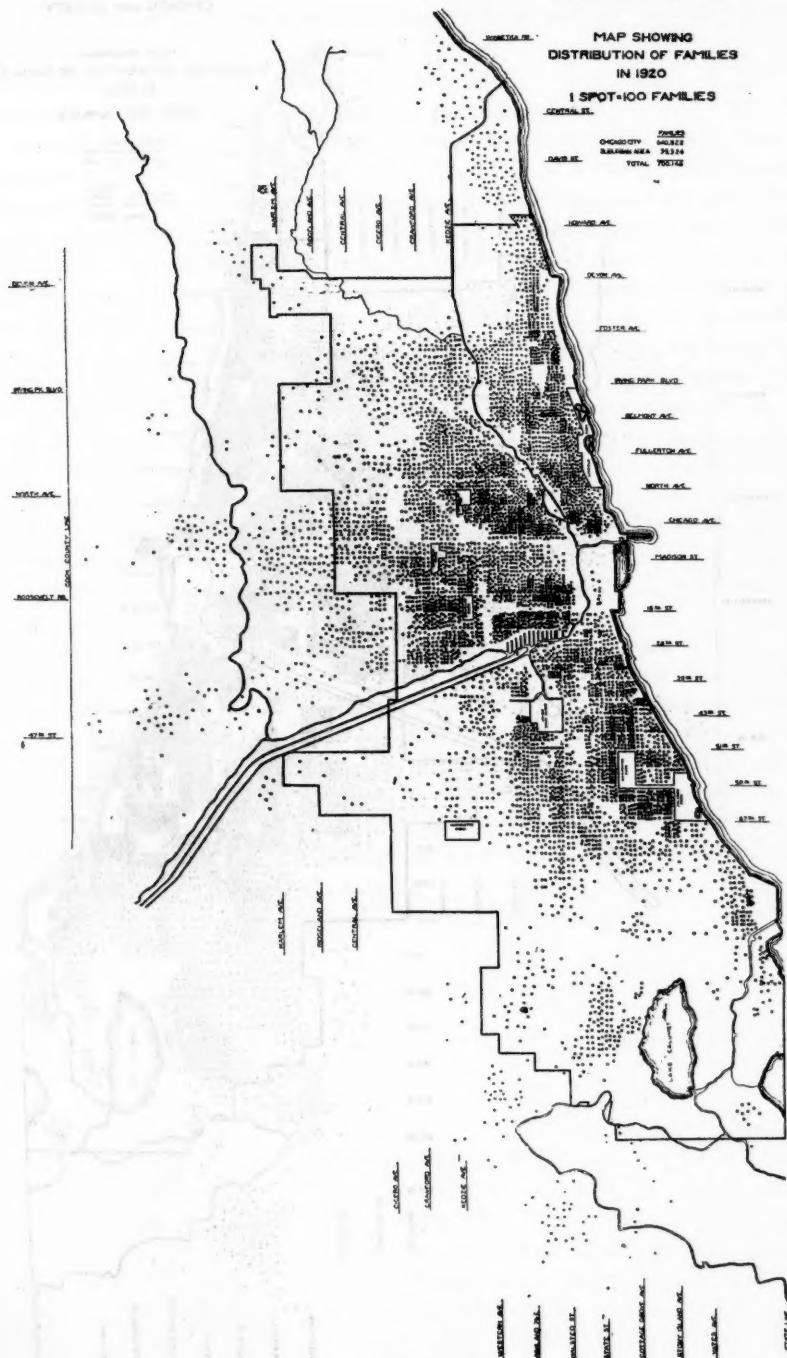
CENTRAL ST.
CHICAGO CITY 70,000
SUBURBAN AREA 70,000
TOTAL 140,000

FIG. 4.

ILLINOIS BELL TELEPHONE CO.
COMMERCIAL SURVEY
OF
CHICAGO AND VICINITY

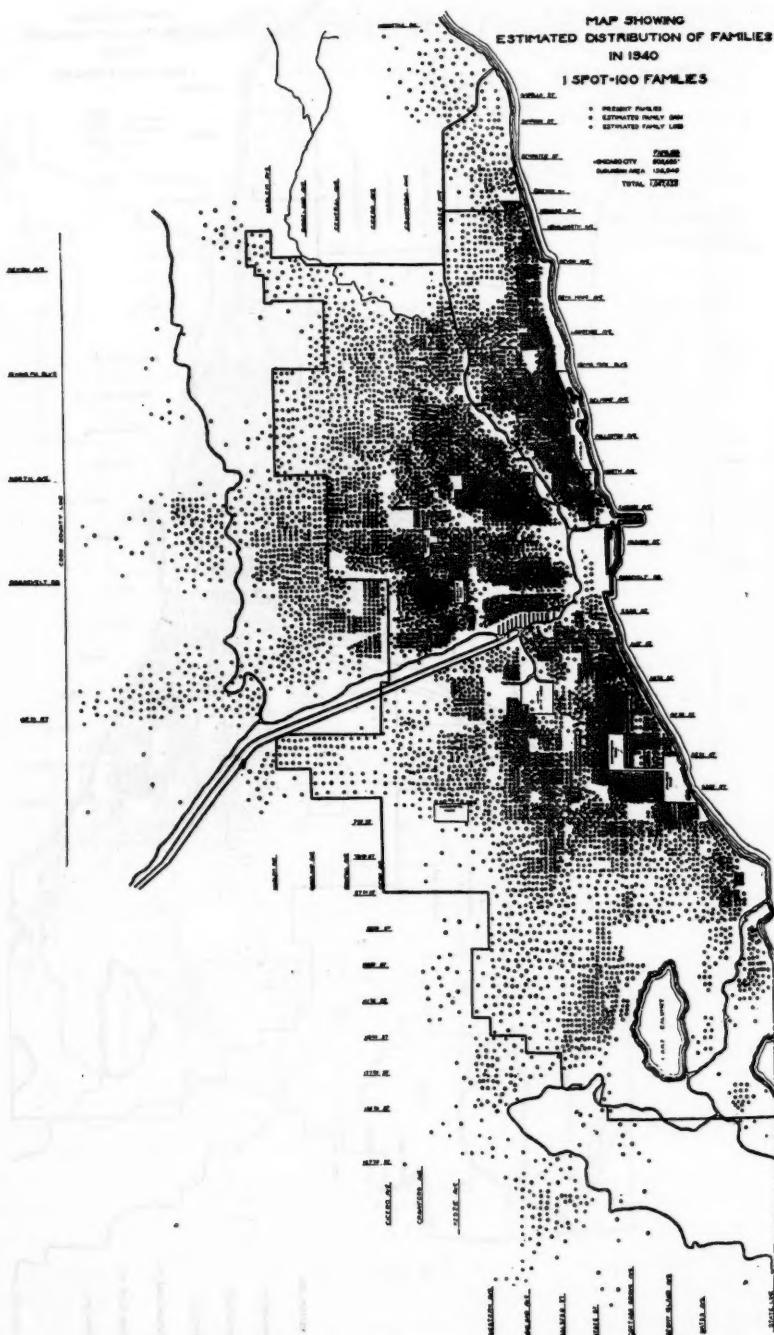


FIG. 5.

project can be proved to the satisfaction of the Board of Appeals, or Adjustment.

Telephone buildings are intended primarily for the housing of delicate apparatus and the handling of conversations between subscribers, and they will be limited to such use by the telephone company wherever the occasional concurrent use of the same building, or lot, for storehouse, garage, maintenance headquarters, or even commercial offices, is considered unnecessary and objectionable at any particular location. As a matter of fact, such extra use is seldom desired by the telephone company in a residential district; and if such a question ever arose, the company would be willing to have it decided by a Board of Appeals. It desires in every way to be guided as far as practicable by the general provisions of any zoning ordinance adopted for the benefit of any city in which it operates, and its possible objection to any such ordinance will always be restricted to such fundamental service and cost items as, in the opinion of its experts, will unquestionably lead either to the curtailment of its service or to a noticeable increase in the cost thereof. It would appear, however, that provisions can be made in zoning ordinances, which should reasonably provide for the telephone problem and, at the same time, be in conformity with the broad fundamental principles on which zoning is understood to be based.

In conclusion, and to illustrate some of the conditions described, the present Telephone Exchange, in Chicago, Ill., as a whole is divided into 32 office areas of which only 7 serve more business than residence stations, 3 of these being in the congested Loop area, and the other 4 adjacent thereto. The other 25 offices serve chiefly residence subscribers, as indicated by Fig. 3. Figs. 4 and 5 show, by spot maps (on which each spot or dot represents 100 families), the number and distribution of families in and near Chicago in 1920 and the number and distribution of families which studies indicate for 1940. From Figs. 4 and 5 it seems evident that it will be impossible to locate 40 central office buildings in Chicago in 1940 and not have many of them in purely residential districts.

THE INFLUENCE OF ZONING ON THE DESIGN OF PUBLIC RECREATION FACILITIES

By C. E. BREWER,* Esq.

Zoning is an undertaking to create a complete and satisfactory living environment for the inhabitants of a city or community. It is an attempt to bring into a community every facility which is vital and necessary to the welfare and happiness of the citizens, and yet not spoil the community as a good place in which to have a home. Transportation, sanitation, streets and water, light and recreation, are necessary facilities to any community. How to have them without injuring the value of one's property is a problem confronting all city planners and city engineers. Badly planned cities, resulting in narrow and crooked streets, poor housing conditions, a lack of sewers and drainage, has caused more illness, discontent, and loss of life than will ever be known.

Work, play, and rest fill the twenty-four hours of each man's life. Where and how a person works is the concern of the progressive business man, as it means profit to him. What a workman does after 7:00 A. M. depends on what he does after 5:00 P. M. of the previous day. The kind of homes is also the concern of every one in the community, for bad living conditions re-act on the health and physical efficiency of the working man. The place and the mode of recreation are the vital problems of every man, woman, and child. Indirectly, recreation affects a vital part of a community's life. Play is an absolute requirement for efficient and continued existence. It is a mental and physical relief from any exhausting activity or environment. It substitutes clean, wholesome use of leisure time from the drudgery of arduous and confining work and for the repressed inherent instinct which one has. Every one has inherent instinctive desires for play. They are generally expressed in creative play. Due to the highly specialized form of industry, in which a man works on a single operation and does not bring the product to a finished condition and has no opportunity to give vent to these inherent creative desires, they must be given expression during his leisure or play time. Therefore, playgrounds and playfields should provide an opportunity to escape from the walls of brick and mortar of the factory, or the dull, toneless environment of the neighborhood. Unfortunately, in most cities too little attention has been paid to the facilities for recreation.

The first attempts to provide open spaces, or "breathing spots", were the public parks. The public park with the "Don't walk on the grass" sign, with its formal flower beds and clusters of shrubbery, did not afford an opportunity for people to give vent to their pent-up and repressed desires for play. Consequently, playgrounds and playfields with large open spaces for all forms of competitive games were developed in modern cities to meet the demand which the public park did not fulfill.

* Commr. of Recreation, Dept. of Recreation, Detroit, Mich.

Parks require large tracts of land for development into formal and artificial beauty spots, whereas a playground requires a small area in comparison. The amount of land required for parks in comparison with that of playgrounds has had an important influence on zoning, particularly if the city has grown rapidly and all the available land was occupied before any thought was given to a plan of acquiring playgrounds.

In zoning, much consideration must be given to the size and development of the playground and playfield. Playgrounds are differentiated from playfields according to the use and kind of activity organized on them. A playground is a small tract of land of from 1 to 3 acres on which playground apparatus is placed and games requiring no special skill are played, a play director being in charge. A playfield is a larger tract of land on which games of skill, such as baseball, football, tennis, soccer, etc., are played.

Zoning has a great influence on the distribution of playgrounds and playfields throughout the city. If the district to be zoned permits business places and factories, and if the tendency in the future of the district is toward more commercial places, then playgrounds should be smaller and situated farther apart. They should be designed for use by the employees of the neighboring factories during and after working hours, and should be situated so that they can be readily sold when they are no longer needed by the city as recreation places.

In districts reserved for residential purposes, the distances apart of the playgrounds should be comparatively short, especially if there are heavily trafficked streets through the district. The various playgrounds in such a district should be of a size to serve best a distinct function, whether it is a small children's playground, a playground for adults, or for both. They should be located throughout the community so that they are easily accessible to those intending to use them. The prevalent impression is that playgrounds should be within $\frac{1}{2}$ mile of each other. A survey recently made in Detroit, Mich., proves the fallacy of this argument. In this survey, an accurate check on the distance, with 21,347 children attending the playgrounds in 1 day, shows that the majority travel less than $\frac{1}{4}$ mile. Table 1 gives the results of the check made in Detroit.

Assuming an average of 10 city blocks per mile, it will be noted that, to be effective, playgrounds should be not more than 2 or 3 blocks apart. If they are placed at greater distances, more than 65% of the children will not attend. This is largely due to parents refusing to permit children to go that far from home to play, especially if it is necessary for them to cross streets with heavy automobile traffic or street cars. With the increasing flow of people from the rural districts to the city, the time is not far distant when it will be necessary to have a playground in every city block, particularly if the trend of building large apartment houses, instead of single homes, increases in the large cities.

Equipment on the playground, the area of free play space, whether tennis courts are desired, and space for other games, must be seriously considered when the boundaries of any playground are fixed. In fact, no playground

should be acquired until the needs of the community and the number of children and adults that would make use of it are ascertained. The plan of development should be definitely settled before the acquisition of any playground is made.

TABLE 1.

ATTENDANCE.		
Distance, in blocks.	Number.	Percentage.
1.....	7 199	33.7
2.....	3 994	18.7
3.....	3 146	14.7
4.....	1 889	8.8
5.....	1 418	6.6
6.....	897	4.2
7.....	629	3
8.....	455	2
More than 8.....	1 720	8.3

In zoning a community, the topographical features must be taken into consideration in planning a playground. One cannot mathematically place one playground here and another half a mile away. Canals, rivers, railroads, and heavily trafficked streets must be taken into consideration. The proximity to factory and commercial houses must be considered by the city planner. It would be foolhardy to place a playground in a community where the children had grown up and married and had left the home for homes of their own and only the old folks remain. It would be equally as bad not to place a sufficient number of playgrounds in a new district, especially where the child population is very dense.

Table 2 shows the distance that children of various ages travel in attending the playground. These tabulations, totaling more than 25 000 children, were taken in Milwaukee, Wis., St. Paul and Minneapolis, Minn., and Detroit.

From Table 2 it will be noted that, in the average city, 50.4% of the children travel $\frac{1}{2}$ mile or less; 74.5% travel $\frac{1}{2}$ mile or less; 86% travel less than $\frac{3}{4}$ mile, leaving only 14% who travel 1 mile or more to a playground. This table also shows that 74.5% of the children in these four large cities travel less than $\frac{1}{2}$ mile to a playground.

It is significant that in St. Paul and Minneapolis less than 35% of the children travel $\frac{1}{2}$ mile or less to a playground, whereas in Detroit, 52.63% travel less than 2 or 3 blocks. This shows that in the larger cities where street traffic is heavy and where the population is increasing rapidly, the playgrounds must be closer together than has been the custom in the past.

In order to provide growing cities with proper playground facilities in the future, the writer believes that any zoning ordinance should require every new subdivision to have at least a 2-acre playground for every 160 acres of land subdivided. Whether this can be legally done must be determined by the Courts through the proper channels. However, it is believed that every realtor can be educated and persuaded that the setting aside of such a small strip of land is in reality a profitable move on his part. People grown wise in the

ways of the city are now demanding that playgrounds be provided for their children and any realtor can sell his property more readily and at a better price if the purchaser knows that a playground will be within a short distance from his home.

TABLE 2.

Age of child, in years.	1/4 MILE.		1/2 MILE.		3/4 MILE.		1 MILE.		MORE THAN 1 MILE.	
	Number.	Percentage.	Number.	Percentage.	Number.	Percentage.	Number.	Percentage.	Number.	Percentage.
Less than 3 years...	952	8.8	190	0.76	88	0.35	26	0.10	37	0.15
3 to 7.....	2 257	9.0	809	3.23	287	1.15	126	0.5	99	0.39
7 to 12.....	4 802	19.2	2 300	9.2	1 110	4.44	600	2.4	463	1.85
12 to 15.....	2 126	8.5	1 179	4.71	654	2.61	274	1.09	398	1.59
More than 15.....	2 461	9.84	1 548	6.19	772	3.08	476	1.9	966	3.86
Total.....	12 598	50.4	6 026	24.1	2 911	11.65	1 502	6.0	1 963	7.85

Zoning should demand that all playgrounds be fenced, not only because fences improve their appearance and that of the abutting property, but because it is a "safety first" measure. Children are not so likely to run heedlessly off the playground under the wheels of traffic if a fence is there to stop them. Playground fences should be constructed with galvanized steel posts and steel wire, heavily galvanized after fabrication. A fence, 5 to 7 ft. high, has been found to be the most satisfactory. The fencing of playgrounds greatly reduces the problem of landscaping as flowering vines, rambler roses, and other climbing species of plants along the fence, greatly improve the playground.

In landscaping a playground, the element of beauty must not be overlooked, yet as much free play space as possible must be preserved. Flower beds or shrubbery beds have no place on the playground, except in the corners of the fence. They would occupy too much valuable space and require an over-proportionate amount of time and labor in maintenance. If shrubs are desired as screens, the fences should be placed back from the sidewalk and the shrubbery planted outside the fence, but not close enough to the sidewalk to interfere with pedestrian traffic. Trees should be planted near the fence or near the apparatus in order to afford as much shade as possible. Trees of low height that will provide a dense shade as quickly as possible should be planted in preference to slow-growing elms.

Surfacing is a big problem. It is difficult to make the grass grow when it is being constantly trampled down, yet a bare playground is unattractive to the children and dust arises, causing much nuisance to the housewife. The proper surfacing for a playground has been the source of much discussion. Cinders are dirty, black, and stifling. Gravel is unattractive, and the stones are too much of an attraction to the small boy who desires to throw them. Tan-bark has not proved satisfactory. Some cities have climates which make it neces-

sary to have surfaces which, in winter, must withstand the constant freezing and thawing. Others require an easy drainage. Some cannot have surfaces which absorb too much heat. Others, because of financial reasons, must have a cheap surface.

No surfacing has yet been found which proves satisfactory under all conditions for every playground. A playground surface must be suitable, that is, porous enough for drainage, yet firm enough to stand up under constant use when it is wet and not raise a dust when it is dry. In Detroit, a surface of limestone screenings and calcium chloride has proved very satisfactory. It is porous, drains easily, can be used soon after a rain, and does not develop soft spots. It is soft in thawing weather, yet packs down readily when the frost is out of the ground. Calcium chloride keeps down the dust and also forms a binder coat to keep the surface firm. This kind of playground surface has a foundation of 4 in. of hard cinders, wet down and rolled (the cinders are kept wet while being rolled), then 3 in. of limestone screenings is next applied. This is wet down and rolled to a true grade. Next, calcium chloride is applied about $1\frac{1}{2}$ lb. per sq. ft. (calcium chloride absorbs moisture from the air and keeps down the dust), then, $\frac{1}{2}$ in. of sharp torpedo sand is applied. The calcium chloride in forming a binding coat with the limestone screenings and the sand gives a firm, smooth, white finish to the playground.

Buildings, especially lavatories and storage space, are required on each playground. The design of such buildings should be equal to or better than that of the surrounding architecture. The buildings should be permanent and of brick or stone. Wooden buildings should not be erected on parks or playgrounds as they soon become an eyesore rather than a benefit to the community. They are also expensive to maintain, as they soon show the effects of the wear and tear and abuse which, unfortunately, the American public gives to its public buildings.

Playground apparatus should be made of galvanized steel pipe, guaranteed against rust. Rusty apparatus frames, and usually those made of wood, are unsightly. The following pieces of apparatus have been considered the minimum necessary for an efficient conduct of a playground: Two sets of steel swings (three swings in each set), one set for boys and the other for girls; one set of kindergarten swings for babies under three years of age; a horizontal ladder for girls; a giant stride for boys; a 16-ft. coaster, or wave slide; a sand-box, 4 by 8 ft., and four teeter-totters.

In summarizing, it has been shown first that zoning does affect the distribution and location of playgrounds, the fencing, landscaping, and architecture of buildings; and second, that the city planner must ascertain the needs of the community and the density of child population in the community, and determine the number of people that would probably use the playground, before any attempt is made to locate a playground in a given district or zone.

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THE INFLUENCE OF ZONING ON THE DESIGN OF TRANSPORTATION SERVICES

By J. ROWLAND BIBBINS,* Esq.

The assigned subject of this paper would apparently confine it largely to rail movement, but it is now impossible to avoid consideration of all surface transport on the thoroughfares of a city. Transportation must be conceived as covering all carriers used in public service. Traffic is simply the by-product, whether *via* rail, water, or "rubber". It is a composite problem, unfortunately not widely appreciated as such, and the street plan is of fundamental importance to local transport, as private right of way is limited to railroads, rapid transit, or grade-separated trunk highways—all very scarce in American cities.

What Is Zoning?—Zoning has been defined, as follows:

"A fair, common-sense regulation governing the use of private real estate." (Hoover Advisory Committee on Zoning.)

"The legal exercise of State police power * * * an amplification of welfare and safety laws essential to orderly city growth * * * broad enough to meet ever-changing conditions. * * * As the primary purpose of City Planning and Zoning is to regulate and distribute the population of a city * * * the safest way to accomplish this is by *Density Regulation*." (Bartholomew.)

"Based upon a frank acceptance of existing conditions * * * also upon judgment as to future growth and requirements * * * the transport system is the chief factor in determining business and residence building." (Whitten.)

"After a scheme of streets, transit, transportation and recreation has been determined upon, it becomes a matter of evident reasonableness to regulate property uses in all parts of the city in accordance with these several elements." (Bartholomew.)

Which Comes First—Zoning, Transportation, or City Plan?—Obviously, these subjects should not be dissociated, yet this frequently happens. The "Municipal Index" cites 200 zoning precedents to-day, but only 75 "comprehensive" city plans:

"Other planning features such as * * * port-development, routing of transit lines, have found place in many planning reports, but the combination of streets, zoning, and recreation into a well-ordered whole is essential to guide the building of the future city."

The writer does not fully share this relative appraisement of the value of control factors, especially of transportation, so often neglected. There is a suggestion of unbalancing here, running against economic laws. For basic transportation plans have all too rarely been studied in sufficient technical perspective or even deeply considered. A wealth of such data should be had from these 200 zoned cities.

A natural fixation arises from topography, geography, hydrography, railroads, prevailing winds, etc. Business is automatically fixed by transportation

routes. These elements cannot be divorced without assuring adequate facilities elsewhere. The defect in the usual city program is that, although zoning control is established, the needed transport facilities are not provided, and rarely planned as a vital part of the program, otherwise destined to defeat or delay.

The Traffic Situation To-Day.—All large cities lay claim to the doubtful distinction of being "congested". How many have sought the basic reasons why? How many are using present facilities to full advantage? In a recent survey the writer found an average efficiency of use of 36 outlet streets to be only 25% of that possible, even assuming solid parking, that is, about 300 vehicles per traffic lane per hour. Good practice should be 1 000 vehicles per hour and one street in the country is to-day carrying 3 000. This survey also showed a daily commercial vehicular movement of one-half that of automobiles and the latter carrying a rush traffic equal to that of the transit system, largely traceable to defective street system. This city is zoned. It is found in Chicago, Ill., that 60% of the store deliveries are made at the curb and that 30% of the street movement is due to "milling" for position. There is 1 vehicle movement down town for every 2 automobiles in the district. The writer found that the ratio in Indianapolis, Ind., to be 1 to 2.5, or less. In New York, N. Y., 70% of the north-south traffic is concentrated, from Fourth Avenue to Eighth Avenue.

The Motor's Growth.—The writer's studies of the increase in motor vehicles have indicated an amazing fact—a uniform rate of absorption for the whole country of the twentieth power of the population, 1905 to 1920. At this unbelievable rate, there would be 100 000 000 motors by 1930, a manifest absurdity. By applying reasonable adjustments, however, 30 000 000 motor vehicles can be foreseen, possibly by 1940, and, in the near future, present factory capacity will be needed to meet renewals and to supply the 5 000 000 new families by 1940, or 31 000 000 people in all. At present, there is in this country one motor vehicle for each telephone,—three motors to each five families—and in California one motor vehicle for each family.

If the California rate is reached for the entire country, the density just predicted will materialize. That this is not improbable is indicated by the fact that the average motor density in cities and towns above 1 000 is already 1.6 families per motor and about 1.7 in those above 2 500. This latter "urban" census group of cities contains about 60% of the nation's automobile registration.*

Meanwhile, cities are experimenting with block signals, one-way streets, etc., usually without adequate facts, surveys, or design, and in desperation, the police adopt "no parking" as the last resource. Detroit, Mich., the motor city (since operating its own municipal railway system), has laid this prohibition on all down-town streets and all the twelve main radial streets for several miles outward, 40 miles of streets in all, that is, the hub and spokes of the business wheel.

* Report of National Automobile Chamber of Commerce, based on the "Motor List."

This is not engineering; it is a stampede. Where are the sober facts, surveys, and carefully worked out plans of experienced authority that justify such drastic measures from a technical or economic viewpoint? The cost of planning would be microscopic, relative to the saving.

How Shall the People Be Served?—Obviously density regulations will fail without transportation service. Private motors will be used until central congestion stagnates everything. It is evident that the needs are not being met, as every new street and transit facility is so quickly overloaded (for example, Michigan Boulevard in Chicago, Ill., and the new subway in Brooklyn, N. Y.). In fact, rapid transit concentrates traffic, increases land values, and makes more congestion, unless it is planned and "integrated" with all other facilities and methods. This broader planning of transportation seems to be the only key.

The Terminal System Controls Capacity and Routing.—The "bottle neck" seems to be the stumbling-block. Railroad men know that more line capacity without terminal capacity is virtually useless. Traffic and transit follow the same dynamic laws—an open book to those experienced in their application. Chicago has only a 2-track loop to serve as a terminal for a dozen or more elevated tracks converging thereon. As a last resort, through-routing was adopted—a mechanical necessity. At present, the station-loading time is the final limit of capacity. The same is true with street cars and bus lines, except for the added obstruction of the police signal time. Street capacity is a scientific problem of the same nature. Cities are still operating 2-track traffic, like the Chicago Loop.

Thirty-Minute Time-Zone Controls Major Settlement.—In transit, 5 min. saved expands this zone 1 mile and 10 min., 2 miles, thus doubling, automatically, the heavily settled areas in most cities. Zoning can control the expansion, but without adequate transport service, zoning must be relatively ineffective. In New York this was recognized in the first zone planning. People turn to rapid transit and railroads when the streets become too slow. Thus, the 30-min. time-zone extends 15 miles along the Chicago North Shore by train, but only 4 or 5 miles on the surface. This is the economic control which no amount of good zoning can, by itself, overcome.

Functional Purpose of Zoning in Transportation.—In order to distribute population rationally, reduce central congestion, relieve trunk thoroughfares of traffic "nodules" or bunched congestion, make possible adequate transportation, speed up that service, and reduce economic waste. What is the measuring stick of "density"? For on the density rests the transport capacity needed. If the limits are too easy, transport lines are overloaded, streets cannot carry their burden, transit is stagnated. It is no solution to invade other streets of the city with many new lines of traffic of equal inefficiency, even if such new lines could be financed. Obviously, to obtain adequate street and transit capacity, higher and higher zoning limitations are required. The widening of a few streets or a few blocks in the central district will not suffice for, immediately, the building height limit shoots skyward several times

faster. The outside zoning density standards in the end form the major control.

Land Values Measure Character and Use.—The entire trend is toward congestion. Which is cause and which effect is now immaterial. Business has encouraged congestion and is now dispersing in desperation. Fig. 6 tells the story. This city is not yet developed to one-third its full building height under the zoning ordinance. What will happen when it is? It has a "twilight zone", or blighted district. The next parallel streets are fully suited for as high-class buildings as "Main Street". Merchants demand car-line terminals in front of their stores, private "no parking" signs, practice curb loading of merchandise and look with "envy, hatred, and malice" on the struggling commerce of competing streets. Where is the "ceiling"? Why not fill up the valleys and develop the slopes?

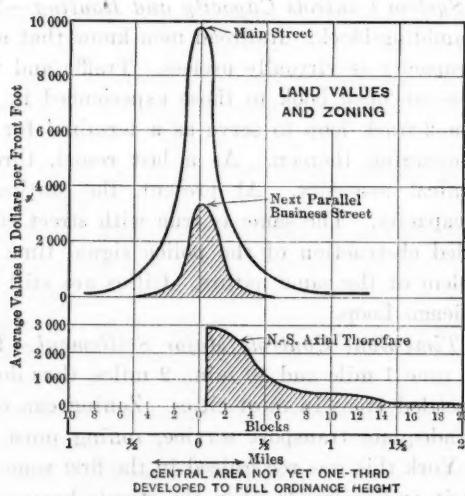
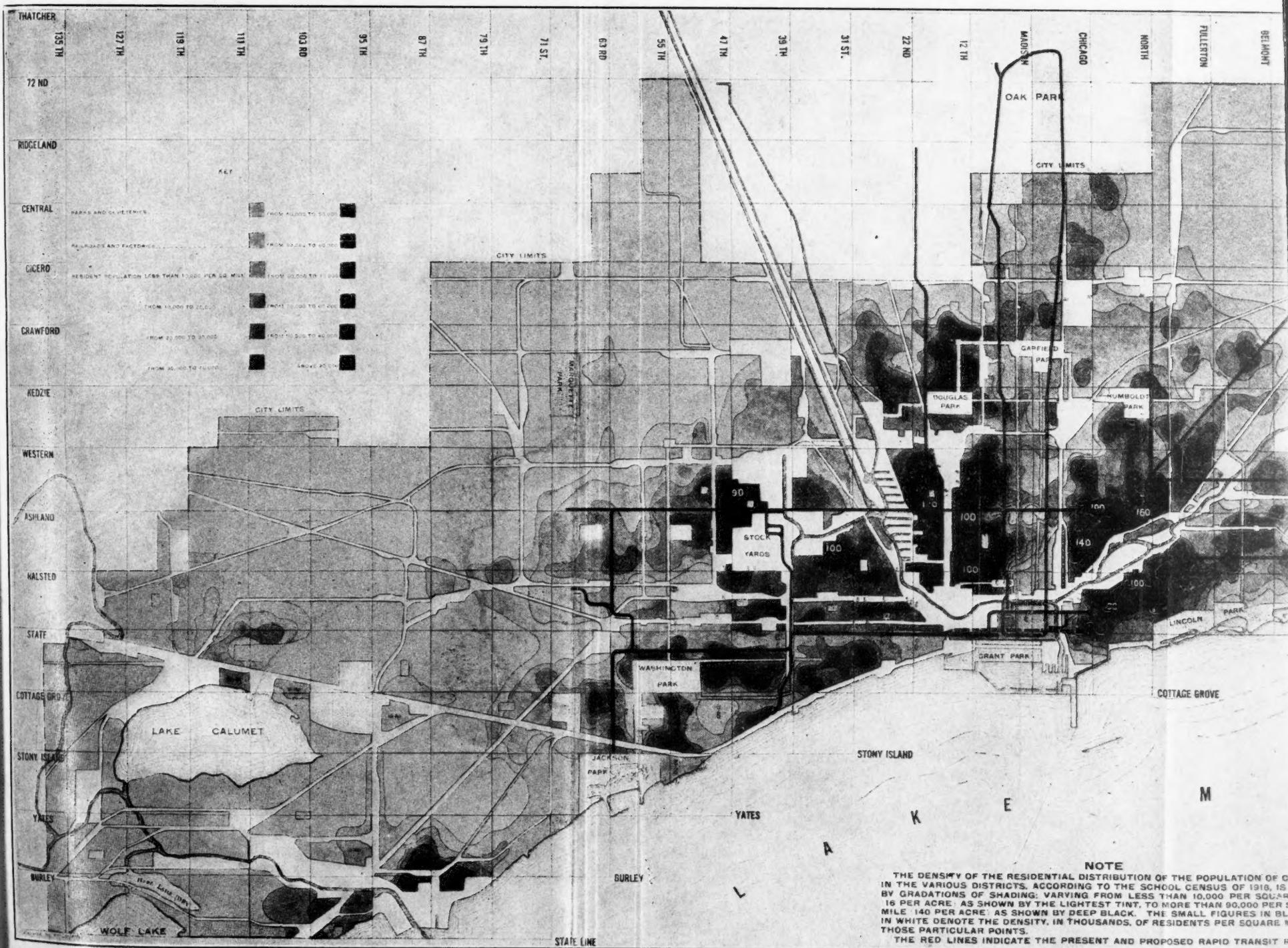


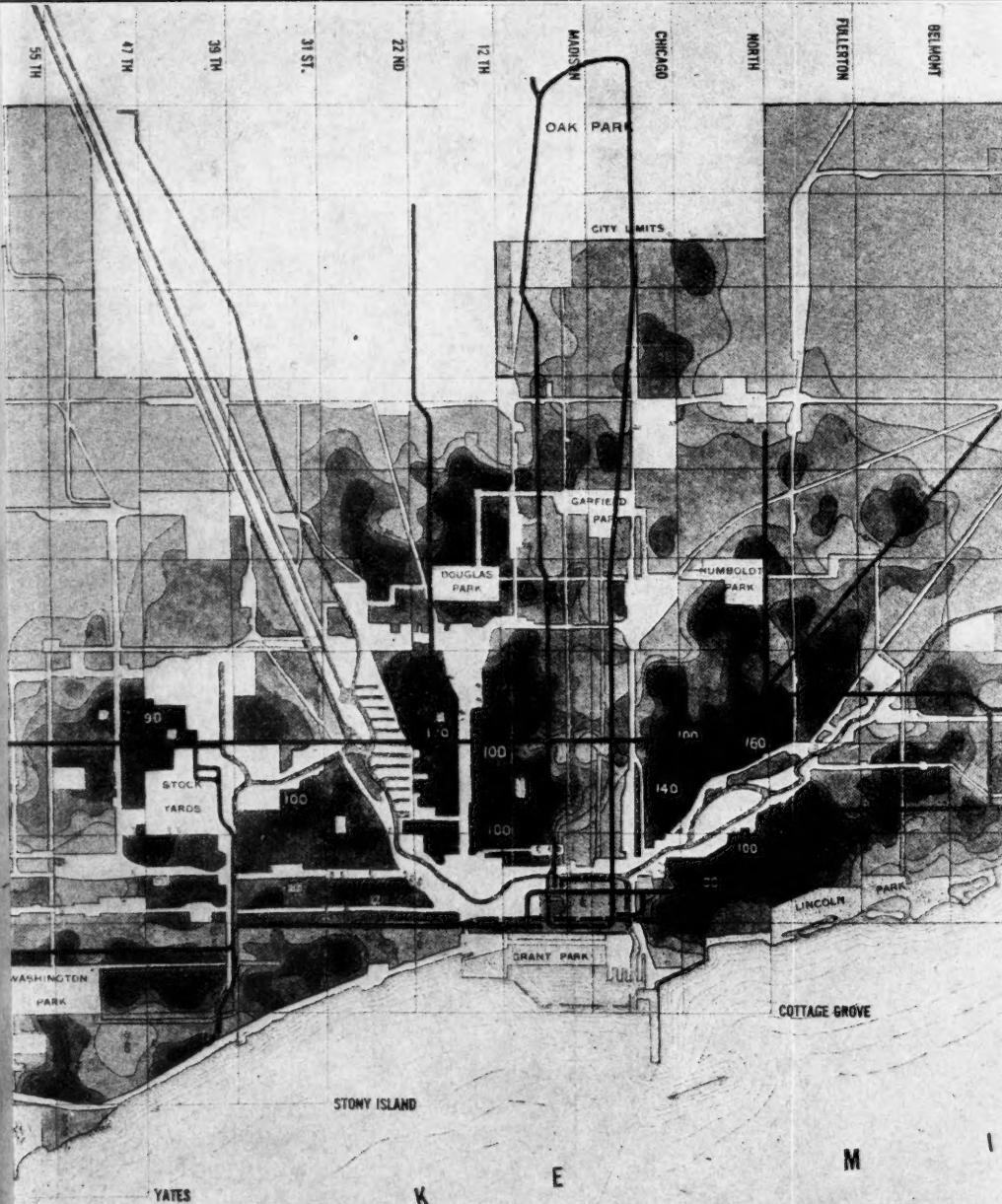
FIG. 6.

Density Profiles Give Definite Characteristics.—Fig. 7 shows clearly the basis which should underlie both zoning and transportation service. It applies equally to the large and the small city. The opportunity for control in the small city, however, is unlimited. In the large city, it is very limited because of established precedent. The City of Chicago is 26 miles in diameter, excluding the suburbs. (Manhattan, superimposed, would only reach half way, that is, from the Stock Yards to the northern city limits.) The population always concentrates nearest its work. The transit fare and the trip time control this concentration more than anything else. Relieve transit, and the time-zone (for the same fare and operating cost) is expanded. Zoning forces expansion without increasing traffic capacity at the throats where it is most needed. It cannot decrease present congestion without such relief. It is not retro-active.

Fig. 8 shows progressive density profiles for Chicago, and Plate I is a topographic density map of Chicago in relation to rapid transit development.



NOTE
THE DENSITY OF THE RESIDENTIAL DISTRIBUTION OF THE POPULATION OF CHICAGO IN THE VARIOUS DISTRICTS, ACCORDING TO THE SCHOOL CENSUS OF 1918, IS SHOWN BY GRADATIONS OF SHADING: VARVING FROM LESS THAN 10,000 PER SQUARE MILE, 140 PER ACRE, AS SHOWN BY THE LIGHTEST TINT, TO MORE THAN 90,000 PER SQUARE MILE, 140 PER ACRE, AS SHOWN BY DEEP BLACK. THE SMALL FIGURES IN BLACK IN WHITE DENOTE THE DENSITY, IN THOUSANDS, OF RESIDENTS PER SQUARE MILE AT THOSE PARTICULAR POINTS.
THE RED LINES INDICATE THE PRESENT AND PROPOSED RAPID TRANSIT ROUTES.

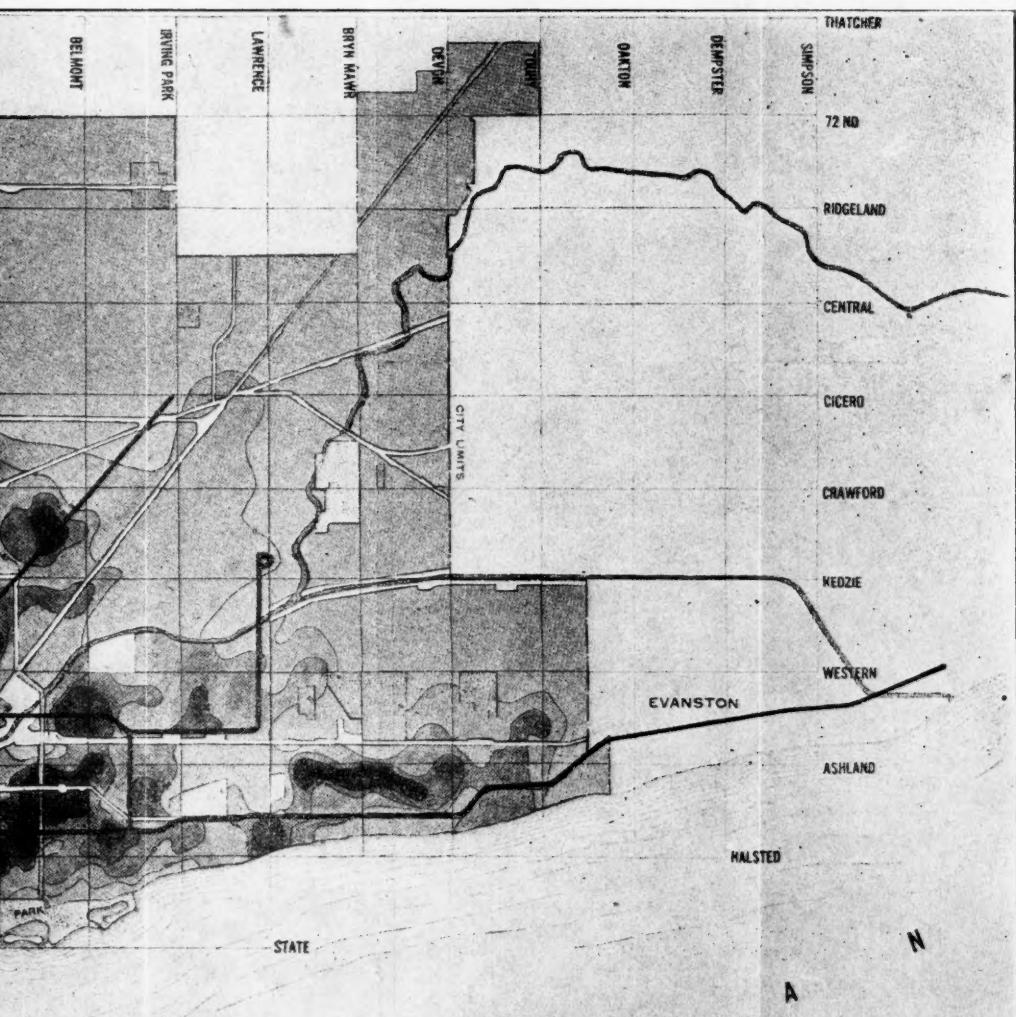


NOTE

THE DENSITY OF THE RESIDENTIAL DISTRIBUTION OF THE POPULATION OF CHICAGO IN THE VARIOUS DISTRICTS, ACCORDING TO THE SCHOOL CENSUS OF 1910, IS SHOWN BY GRADATIONS OF SHADING: VARYING FROM LESS THAN 10,000 PER SQUARE MILE TO 16 PER ACRE; AS SHOWN BY THE LIGHTEST TINT, TO MORE THAN 90,000 PER SQUARE MILE, 140 PER ACRE; AS SHOWN BY DEEP BLACK. THE SMALL FIGURES IN BLACK IN WHITE DENOTE THE DENSITY, IN THOUSANDS, OF RESIDENTS PER SQUARE MILE IN THOSE PARTICULAR POINTS.

THE RED LINES INDICATE THE PRESENT AND PROPOSED RAPID TRANSIT ROUTES.

PLATE I.
PAPERS, AM. SOC. C. E.
FEBRUARY, 1925
BIBBINS ON
ZONING AND TRANSPORTATION SERVICES.



RELATION OF THE PROPOSED IMMEDIATE
DEVELOPMENT OF THE RAPID TRANSIT SYSTEM TO
THE RESIDENTIAL POPULATION OF CHICAGO

ACCOMPANYING REPORT OF
CHICAGO TRACTION AND SUBWAY COMMISSION

TO THE

CITY COUNCIL OF THE CITY OF CHICAGO

1916

POPULATION OF CHICAGO
IN 1910, IS SHOWN
00 PER SQUARE MILE
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PER SQUARE MILE AT
Rapid Transit Routes.

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Since 1860, the population crests moved outward from the 1 to 2-mile radius to the 4 to 5-mile radius in 1916, and to the 5 to 6-mile radius in 1920.* For perhaps twenty years, there has been no increase in the trunk-line transit capacity of streets, except of a minor nature, but congestion and average haul have constantly increased. Chicago still does business on the mountain peak of land values—the Loop, 8 by 12 blocks—with an atrocious blighted district surrounding it. A significant change, however, is coming, for it was recently reported that merchant advertising outside the Loop amounted to one-third of that of the Loop stores. Shades of "State Street"!

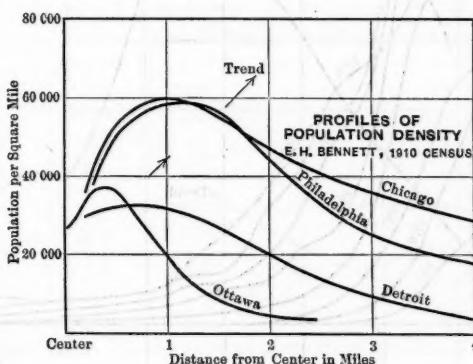


FIG. 7.

What Can Zoning Accomplish?—Zoning seeks control through use, height, and area (or volume) limits, an excellent basis, especially the set-backs, both in residential and high building districts. This height is usually a multiple of the street width and automatically increases if the street is widened. Widening, however, usually has little effect on track capacity (except in relieving traffic interference), because the street is still limited to double-track traffic. The central district densities in Table 3 serve to illustrate ultimate possibilities.

The possible densities shown in Table 3, or even half of them are appalling. The half-mile zone in Chicago, the Loop, is as yet only half built up; and in Indianapolis, it is only about one-third the full ordinance height. Ten-car rapid transit trains, of 125 people per car, with 1-min. headway, have capacities of only 75 000 people per hour; with 30-sec. headway, 150 000 people per hour. For such densities surface transit is hopeless, and bus transit still more so.

D. L. Turner, M. Am. Soc. C. E., reports that the New York steam railroads handle daily a passenger transit traffic about equal to 20% of the entire railroad traffic of the United States. The late A. H. Smith, President of the New York Central Railroad, predicted a catastrophe in New York within the decade, if the passenger transit problem were not adequately dealt with. Height zoning seems one of the most effective measures if stringent enough, and progressive height taxation has been proposed as an additional curb. The

* "Extension of Chicago Traction and Subway Commission's Curves", by Mr. R. F. Kelker.

skyscraper is already declared to be an economic misfit. It has been stated by F. H. Bartlett, President of the Chicago Real Estate Board, that:

"The tall building is responsible for raising ground value above the possibility of the earning power. * * * The skyscraper in Chicago is an economic financial blunder."

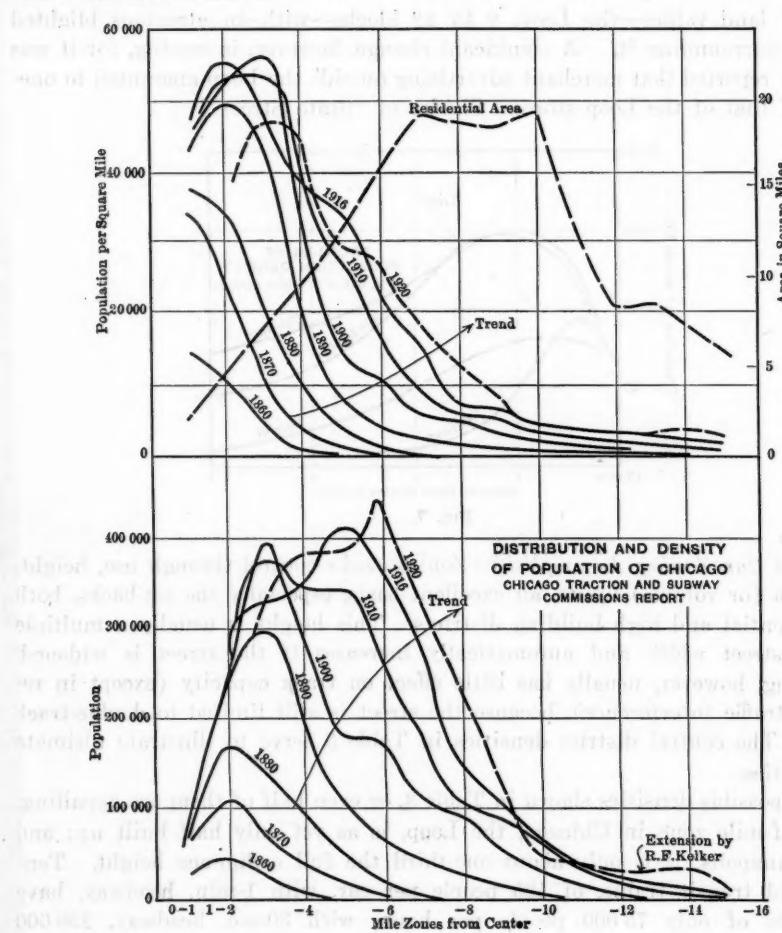


FIG. 8.

Area-density zoning for the residential districts is an excellent control if the limits are placed sufficiently low. The density limits of the outer zones seem to range from 3 750 to 5 000 and 7 500 sq. ft. per family. For the close-in or "peak" districts, the limits range from 300 to 600 sq. ft. per family, or are "unrestricted". The results are illustrated in Table 4.

Translate Table 4 into results. Fig. 9 shows: (1) the possible or ultimate density; and (2) the actual density to-day for a city of about the 2 000 000 class. The densities are gross, streets included. The upper curve shows the zoning ordinance standard, and the lower curve, the profile of a 1-mile strip

along the most densely settled thoroughfare of the city, thus giving tributary population to the transit line bisecting it. Thus, a "5 000" zone permits a gross density of about 14 000 persons per square mile; a "2 500" zone permits 27 000; a "1 250" zone 54 000; and the "apartment" zone more than 100 000 per square mile. The present densities are far less than these limits, being 21 000 maximum in the second mile apartment district.

TABLE 3.—BUILDING HEIGHTS ALLOWED.

Street width, in feet.	HEIGHT TIMES STREET WIDTH, IN FEET.			
	1.	2.	3.	4.
60.....	60	120	180	240
80.....	80	160	240	320
100.....	100	200	240	400
				{ Buildings with setbacks could exceed these heights.
OCCUPANTS PER SQUARE MILE, IN MILLIONS.				
60.....	1.1	2.1	3.2	4.4
80.....	1.4	2.8	4.4	5.7
100.....	1.8	3.6	5.3	7.1
				{ Twelve blocks per mile; 80-ft. streets —35.6%; 9 900 000 sq. ft. net; 100 sq. ft. per person; 10 ft. per story; 278 000 people per story.

This means that these limits permit a population from two to eight times or more in present areas. Zoning does not yet operate, by itself, to "spill over" excess population into adjacent zones. This city regards itself now as "congested". Its maximum square mile density is 21 000. The A_5 District permits well over 100 000. In 1916, Chicago's Ghetto had a density of 160 000; that of New York, 640 000.

TABLE 4.

Density limits, in square feet per family.	SIZE OF LOT PERMITTED, IN FEET.					POPULATION PER SQUARE MILE.	
	One family.	Two families.	Three families.	Four families.	Five families.	Net.*	Gross.
7 500	50 by 150	.....	.....	.....	.....	15 000	9 000
5 000	40 by 125	.....	.....	.....	.....	23 000	14 000
8 750	.....	50 by 150	.....	.....	.....	30 000	18 000
2 500	.....	50 by 100	50 by 150	.....	.....	45 000	27 000
1 250	.....	.....	40 by 94	40 by 125	.....	90 000	54 000
625	.....	.....	30 by 83	35 by 90	180 000	108 000	

* Assuming 40% street and park area deducted from gross area.

Thus, the limits in the inner zones are the most important from a transportation outlook. They control or congest the throats of traffic. The maximum limits on the outer zone are of least importance, because only a small number of people are affected and these are inclined to use private means of transport.

Transit service to this 1-mile strip containing 70 000 people would require about 30% more track capacity than a 2-track surface line could effectively

render. Actually, two car lines serve it in addition to an automobile service that is actually carrying a rush-hour traffic as great as the transit system, taking the business district as a whole. What will happen with two to five, or more, times the present density?

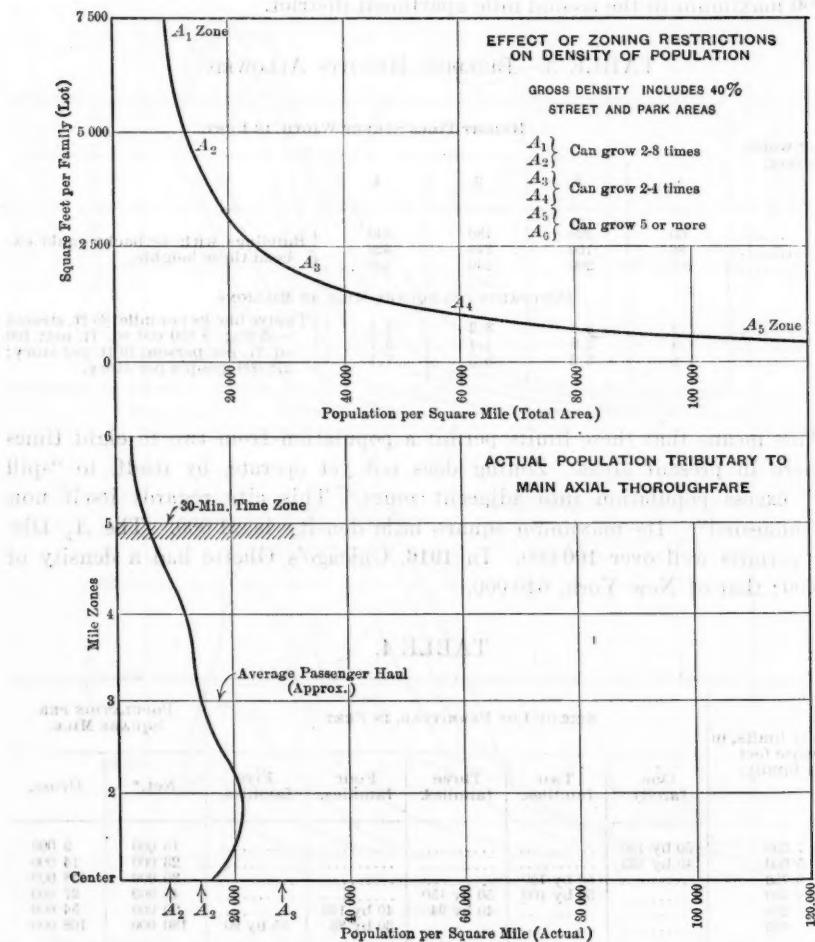


FIG. 9.

Zoning by Transportation.—Fortunately, there are some quick methods of control, known to transportation men. Let us pass over the zone-fare system at once, for it is centripetal, not centrifugal in its action, like a rubber band, urging people toward the center to reduce the cost of transport. A higher fare for the whole city brings a more wholesome development. Apparently, Americans will not tolerate European practice in this regard.

The zone system of short-lines, or tapered service, however, can exercise control if the service is extended somewhat beyond the present needs and

short terminals are located so as to encourage the building up of proper sub-centers. This system is economical, and conduces to transport efficiency—maximum service for the lowest fare where needed. It is always opposed by real estate speculators just beyond the sub-terminals. Fewer short-line terminals have the same advantage and tend to expand the central business districts.

Zone control can also be accomplished through special co-ordinated transport services—cars in the denser areas, bus feeders beyond, and limited-stop express buses (with differential fares) for long haul to established sub-centers, as in rapid transit express service. These methods make the best use of the limited street capacity of the throats as well as the track capacity. Such a zone-fare system is justifiable.

Recapitulation.—What zoners might consider:

1.—The establishment of an economic "ceiling" in the central districts that will padlock the "mountain tops" more effectively. There is plenty of "camping ground" on the slopes and in the valleys.

2.—More drastic area restrictions in the close-in residential districts, because the present limits are of relatively little effect in dispersing the great mass of the people from the throats.

3.—Zoning might aim at positive control within double the present population, and not wait for it to multiply five or ten times. The lower the density to-day, the greater the opportunity of accomplishment.

4.—Zoning should be based on, and not precede, a thorough street, traffic, and transit plan, developed for a city at least double the present size, and with street and track capacities properly designed for the greater densities to be permitted by zoning—if they are permitted.

5.—Mass-decentralization will remain potential rather than real unless the "ceiling" is lowered faster or traffic deliberately permitted to strangle the central district and effect its own crude cure.

What the Transportation Plan Can and Should Do.—

1.—Exercise more positive control over excessive density and throat concentration to serve best and develop various tributary regions of the entire metropolitan area.

2.—Establish operating methods and services best suited to the needs of various classes of patrons (including equipment, service schedules, routing, speeds, loadings, stops, fares, transfers, train operation, etc.)

3.—Design terminal routing to obtain more uniform density of occupancy in the central district, facilitate easy movement across it, and encourage logical outlying terminal sub-centers, cross-town lines, etc.

4.—Plan transport services as far in advance of proportionate settlement as may be warranted by the earning capacity permitted for the older established part of the system. In view of the restrictions and competition recognized by the public, it may be necessary to resort to partial local-district assessment for these outlying utility services, in proportion to the resulting benefit; or to relieve transit of the track-paving burden, which often costs as much as the track structure itself.

Conclusion.—Zoning is vastly beneficial to orderly development, checks glaring misuses, and, as now administered, will ultimately exercise a restraining influence on mass density, but unless standards are raised, it cannot hope to turn the tide of growing congestion promptly enough to meet obvious traffic needs of the immediate future. Zoning needs transportation to effect real decentralization.

Transportation, if designed for the purpose and intelligently administered, offers the quickest and most positive control, including thoroughfares, traffic organization, transit, motor-bus, rapid transit, interurbans, and railroad commuter service and terminals. All are part of the control system and should be developed together, not in competition.

This metropolitan control is so critical, in present and future aspects, especially "traffic congestion"—the clear result of unpreparedness—as to warrant placing this important phase in the hands of a skilled technical commission, adequately financed and allied with all city plan developments, having responsible charge of the design or planning of such an integrated transport system as will provide most promptly this desirable control and schedule the most practicable future steps. Such a commission should be sympathetic to and support the zoning and city planning movements for the more rapid progress of all. Without adequate transport facilities, all will fail of more than potential achievement.

TABLE 5.—ZONING RE-ALLOCATION IN A LARGE CITY.

	Percentage before zoning.	Percentage after zoning.
One-family houses.....	12	3
Two-family dwellings.....	8	19
Apartments.....	4	13
Commercial.....	5	14
Manufacture.....	13	25
Streets and alleys.....	23	23
Parks.....	3	3
Vacant and other.....	31	none
 Summary : Dwelling area : Before zoning, 24% of total city area. After " 95% " " "		
Business area : Before " 18% " " " After " 38% " " "		
Streets and parks : Before " 27% " " " After " no increase in area.		
Net usable area for residence or business..... 73%		
 Increase from zoning : Apartments..... 186% area. Two-family..... 146% " Commercial..... 184% " Manufacture..... 88% " One-family..... 76% (decrease)		
 Approximate density : Population per square mile before zoning : One-family..... 24 200 gross area 31 500 net, less street Two-family..... 49 100 " 63 500 " " Apartments..... 88 500 " 106 000 " " Average..... 43 500 " 56 500 " "		
 Approximate distribution of population before zoning : One-family..... 27% Two-family..... 36% Apartments..... 36%		

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It must be apparent that rail and industrial traffic—passenger, freight, steam, and electric—is rapidly shifting to public streets and highways. The element of proper economic compensation for use can be determined on an equitable basis. The point is, this new traffic burden is here or is on the way. Cities average 800 miles of paved streets per million people, some having 1 500 to 2 000 miles.* This means a cost of \$40 000 000 to \$100 000 000 per million people served. City population will increase 25 000 000 by about 1940. "Traffic" multiplies many times faster. Increased transport capacity must come through (a) more "right of way"; or (b) higher use-efficiency. The cost of the former method is staggering. Which shall it be?

Table 5 shows the re-allocation of areas in a large city recently zoned. Note that with 143% increase in residential, 186% in apartment, and 186% in commercial areas, street areas remained static.

American cities should take warning from the present débâcle of London traffic, with its entire lack of co-ordination and control. This great public issue has reached a stage demanding the highest technical skill and broadest experience, just as in zoning and other specialized phases of the metropolitan plan.

* The "Municipal Index", based on survey by The Asphalt Association.

ZONING AND WATER SUPPLY

By H. MALCOLM PIRNIE,* M. AM. SOC. C. E.

Zoning in relation to water supply is not new, and water supply engineers are familiar with the idea. Growing cities in hilly country early found it necessary to divide their distribution systems into low and high-service districts, and successive building developments occupied the areas adequately served with water. In these cases the water supply exerted considerable influence in restricting periodical growth within certain limits of elevation. The shores of many rivers, due to the need of large quantities of water for manufacturing purposes and the development of available water powers, became factory zones in the infancy of cities. In fact, the location of many cities was primarily due to an adequate water supply for industrial purposes. The height, bulk, and inflammable nature of buildings determine the water facilities for adequate fire protection and where these have been regulated by building codes, fire protection zones exist, in which different water pressures, capacities of mains, and types and spacing of hydrants are provided. Since the general acceptance of the germ theory of disease there has existed also an exercise of the police power over the use of private property lying within the watershed areas of public water supplies to prevent their pollution, which established zones of sanitation.

The question under discussion has to do with the relation between zoning for height, bulk, and the use of buildings and the water supply. Obviously, the well ordered zoning of growing communities will effect considerable saving in first cost and cost of reinforcement of the distribution systems. If the plan of a city indicates the limits of its industrial sections, its areas dedicated to high buildings, to apartment houses, to closely built two and three-family houses and to one-family houses, and the zoning ordinance places limits within the various areas on the height and bulk of the buildings, the present and future water requirements of the areas can be closely estimated. The distribution system may then be designed for the ultimate development and parts of it installed from time to time as required. If the early development of an area is scattered, a few of the ultimate mains may be laid with small, short-lived, steel pipes in intermediate streets. In this way, every cast-iron main that is installed will remain in service indefinitely. Before streets are paved, the proper water main with service connections, gates, and hydrants, can be installed.

Streets must accommodate pedestrian and vehicular traffic, street-car tracks, elevated and subway rapid transit lines, electric light and power cables, telephone, telegraph, and signal conduits, sewers, gas pipes, and water mains, and, in some cities, the allocation of space above and below ground adequately to provide for these utilities, has become a serious problem. New York found it expedient to drive a pressure tunnel under Manhattan Island, with

* Cons. Engr. (Hazen & Whipple), New York, N. Y.

risers connecting with the existing distribution mains to supply the large and increasing consumption in lower Manhattan and Brooklyn. In spite of the great cost of this construction, it was demonstrated to be much less than the cost of equivalent service through additional pipe lines, even if it were possible to get them into the already crowded streets. A similar tunnel has recently been recommended to reinforce the overtaxed distribution system of Philadelphia, Pa. Such difficult works are the result of disregard for the proper relation between the width of streets and the height, bulk, and use of buildings on the abutting property.

The past uncertainty as to the trend of building has resulted in the replacement of small mains with large mains under the most difficult construction conditions. The removal of pipes that could have served the original type of development for many years, the cutting and replacing of pavements, and the interference with traffic, are constant sources of economic loss in American cities. When a residence street that was adequately served with a 6-in. main gives way to a block of apartment houses and hotels, lots that were formerly supplied through $\frac{3}{4}$ -in. service pipes call for much larger services. The use of flush-valves in these buildings increases the peak demand for water, and the resulting inadequacy of the water main sometimes is not discovered until after an expensive pavement has been laid. The effect extends to connecting mains and the remedy often requires the cutting of pavements and the replacement of small mains with larger ones throughout a considerable area. The construction of high apartment houses in a relatively high residential area may make it necessary to install a booster pumping station and establish a high-service district. Such an area formerly may have been adequately served with water under the general distribution pressure, but with the substitution of high buildings for low widely separated houses comes the need for greater pressure for fire fighting and for giving service on the top floors. Thus, among the many unnecessary costs attendant on haphazard city building, the wasteful expenditures for water facilities command an important place. Stability in existing water-works structures and in present provisions for the future water supply of a community is dependent on stability in building, and may be secured by the early adoption of a carefully prepared zoning plan and ordinance.

In preparing a zoning plan, the water supply must be given due weight with all other purposes in view. Water has been and still is about the cheapest of all public necessities. Its cost in the future, however, will be greatly increased in some communities if the city plans are made without consulting the water authorities. It is possible even to destroy an existing source of water supply by disregarding this phase of the problem, thus burdening the city with a cost for new works out of proportion to the benefits resulting from zoning.

A striking instance of what can happen to a city water supply when it is lost sight of in the midst of other, and for the moment more spectacular, developments exists in the present situation at West Palm Beach and Palm Beach, Fla. These rapidly growing cities are situated on the east coast of

Southern Florida, somewhat more than 40 miles east of Lake Okeechobee. On the western edge of West Palm Beach, about 2 miles inland from the Atlantic Coast, are two shallow, fresh-water lakes, which are splendid natural impounding reservoirs. West of the lakes are the Everglades, with a general slope of 1 ft. in 4 miles from Lake Okeechobee to the coast. The West Palm Beach lakes are in one of the natural outlet depressions which formerly discharged great quantities of water from the Everglades and were capable of supplying water to a population many times that of the present cities. The Everglades drainage operations have recently diverted the flow from the lakes and the area remaining naturally tributary to them is not large enough to furnish the water needed now. In order to avert a water shortage, it has been necessary to purchase large tracts of land and to construct several miles of canals by means of which some of the lost drainage area has been reclaimed.

If some method can be found whereby the needed catchment area can be protected from further deep drainage operations, the present source of supply can be saved. Otherwise, the cities must choose between a supply from Lake Okeechobee, pumped through a 45-mile pipe line, and a supply from the West Palm Beach Drainage Canal which is subject to considerable pollution, is extremely hard, and would require expensive treatment. It is clearly best to conserve the present supply and to reclaim additional drainage area by extending canals as required to meet the growing demand for water, provided the investment in such works is justified by zoning the area against other drainage operations.

Under Section 3 of the Standard State Zoning Enabling Act of the U. S. Department of Commerce, it is pointed out, among the other purposes in view, that the zoning regulations shall be made in accordance with a comprehensive plan and designed to facilitate the adequate provision of water. The adoption of this Act in Florida would make it possible for the City of West Palm Beach to establish a water supply zone by extending its limits to the west. The size of the zone would be such as to furnish water for a long period in the future. Within the zone the lowest lands would be set aside as dredging areas from which the material would be obtained to fill the intermediate land. The water areas thus formed would become lagoons of the lakes or canals, and marginal parkways would be established to protect the water from pollution. If houses were built in the area near the lakes their sewers could be extended out of the area to points north or south.

A comprehensive plan of development of such a water-supply zone could be effected that would benefit all lands within it and, at the same time, regain a supply of good soft water sufficient for many years. The marginal parkways would furnish several miles of attractive drives near the cities, and the bordering land with its view of parks and lakes would have great value as residence property. The fine deep sand underlying this area would largely purify any unavoidable pollution on it, and keep the water in the lakes in satisfactory condition for use as a water supply after filtration. The lagoons and canals would be of such capacity that the ground-water level would be maintained sufficiently near the surface to support vegetation even in dry

seasons. The elimination of the shallow swamps now covering the bulk of the area would destroy the mosquito-breeding grounds nearest the cities. There can be no doubt that such works would increase the value of all remaining property more than enough to compensate the owners for the parts of the area dedicated to lagoons, canals, and marginal parks.

In the adequate provision of water there are various degrees of aid that can be obtained through proper zoning. In the situation just outlined, the zoning of the catchment area is the only practical means by which an excellent and most economical source of water supply can be preserved. In all communities, however, there will be financial loss due to the lack of stability in water-works building, as long as haphazard city building is allowed to continue. The importance of zoning in stabilizing the water-works business and continuing water as a relatively cheap commodity, is just as great as it is in otherwise conserving property values and promoting the health, safety, morals, or the general welfare of communities.

site to develop power and water sufficient to control the Colorado River and to irrigate the entire valley. Surface irrigation will cover about one-half of the valley. The other half will be irrigated by diversion dams, which will furnish water to areas up to 10 miles from the river.

THE COLORADO RIVER PROBLEM

Discussion*

BY MESSRS. LOUIS C. HILL, C. S. JARVIS, E. W. LANE, RAYMOND A. HILL,
E. B. DEBLER, AND WILLIAM KELLY.†

LOUIS C. HILL,‡ M. Am. Soc. C. E.—It is generally agreed that the Colorado River must be controlled not only for flood protection but for irrigation and the development of power. As stated by the author, however, protection of the lands along the river and in the Imperial Valley from damage by inundation is of primary importance. No plan that limits this protection should be considered.

The determination of what ultimate development of the Colorado River will give sufficient protection from floods, will irrigate most economically the maximum area, and will return the largest net income from the generation of power, is a problem not yet solved. Any schedule of development leading to such ultimate control and use of the waters of the Colorado River will be greatly influenced by such economic factors as the rate of agricultural development within the Basin and the rate of increase in the use of power throughout the entire Southwest.

As the generation of power will be of secondary importance to irrigation and as both must be considered in the light of their effect on the control of floods, the speaker will touch on these subjects in that order.

Power Development.—If the entire Southwest were thickly settled and industrially developed it would be logical to create the first storage reservoir on the Colorado near the upper end of the Canyon Section. The regulation of the flow from this reservoir would greatly increase the available power at each site below. Furthermore, this regulation would reduce the cost of foundation work on any dams built subsequently in the canyon.

Before being called by the U. S. Bureau of Reclamation and by private power interests to study the control of the Colorado River, the speaker was of the opinion that the Glen Canyon site should be developed first, in spite of the distance to a power market. However, after personal investigation of this site at the head of the canyon and of the Boulder Canyon or Black Canyon sites at the lower end, he is convinced that, under the physical and economic conditions, the net advantages of the lower site outweigh those of Glen Canyon as the location of the first large reservoir. Glen Canyon is about 100 miles farther from a railroad than Black Canyon and 250 miles farther from the principal power market.

* Discussion of the paper by William Kelly, M. Am. Soc. C. E., continued from November, 1924, *Proceedings*.

† Author's closure.

‡ Cons. Engr. (Quinton, Code & Hill), Los Angeles, Calif.

Although the depth to bed-rock at Glen Canyon is about 80 ft. as against 124 ft. at Black Canyon, there is considerable doubt as to the suitability of the Glen Canyon sandstone for the foundation of a dam as high as that required for proper control of the Colorado River. It is no doubt true that tests of dry samples indicate ample compressive strength, but this material will be subjected to high hydrostatic pressure so that its action when wet must be considered. Samples of this sandstone were secured by the speaker himself from an excavation made in the side wall of Glen Canyon by the Southern California Edison Company for the purpose of obtaining fair samples. After one of these rock fragments has been in water for a few minutes, it may be easily broken and crushed into sand particles with the fingers.

Even if careful and extended tests should show sufficient strength and resistance to percolation to warrant the erection of a high dam, this sandstone is unsuitable for use in the construction of either a rock-filled or a masonry dam. The aggregate would have to be obtained several miles downstream from the dam site.

In his conclusions, the author has stated that a high dam should not be built in Boulder Canyon or Black Canyon because the ultimate power development under the U. S. Bureau of Reclamation plan would be curtailed by 300 000 h.p., due to the loss of 80 ft. of head between the Boulder Reservoir and Diamond Creek. The selection of Black Canyon as the site of a storage dam should not be condemned arbitrarily because the Federal Power Commission believes that too high a dam is provided in the preliminary plans of the U. S. Bureau of Reclamation.

In all the plans proposed by the author, he has considered that the elevation of the head-water above each dam should equal the tail-water level of the next dam. The least lowering of any reservoir must result accordingly in the loss of just that amount of available head in the development of power.

The requirements for irrigation in the Lower Basin will seldom correspond to the quantity of water that will be released from the upper storage reservoirs for the development of power. Consequently, re-regulation of the water released for power must be effected in some reservoir at the lower end of the Canyon Section. As this re-regulation will result in unavoidable fluctuations in the level of the lowest storage reservoir, provision must be made in the ultimate development to prevent a corresponding loss of head and power.

It has been suggested by Mr. R. A. Hill that a dam, which would be sufficiently high to back water to the foot of the power dam at Diamond Creek, should be constructed ultimately across the upper end of Boulder Reservoir, probably at either Spencer Canyon or Bridge Canyon. The normal low-water level in Boulder Reservoir should correspond to the river level at this intermediate dam, and during periods of high water this dam should be partly submerged. In spite of inevitable fluctuations in the level of Boulder Reservoir, it would be practicable to use in the development of power all the head between these reservoirs by the installation of variable head turbines arranged to operate when submerged as much as 100 ft. Furthermore, this plan would eliminate the loss of 80 ft. of head below Diamond Creek, cited by

the author as one of the main objections to a high dam at Boulder Canyon or Black Canyon.

It will be many years before the construction of this intermediate dam becomes necessary, but the speaker believes that it should be considered as part of the ultimate development on the Colorado River. It would not be difficult to construct; the flow of the river from above would be under control; and Boulder Reservoir would periodically be low enough to unwater the dam sites in Spencer and Bridge Canyons.

In order that the maximum beneficial use may be made of the waters of the Colorado River, a large amount of storage to equalize the flow over several years must be provided for irrigation as well as for power. Although the author has given some weight to this in his plan for the development of power, he has not provided sufficiently for irrigation, which should be given prior consideration.

Irrigation.—Water storage for irrigation should be as close as possible to the lands to be served. If this were the only consideration, the selection of Boulder Reservoir—to be created by a dam in Black Canyon—would be without material opposition as this reservoir is only 300 miles above the Laguna Diversion Weir, as compared with nearly 700 miles for the Glen Canyon site.

Storage reservoirs above the Canyon Section should be built as the need arises, and should be operated to best satisfy the power demand. These reservoirs, when the ultimate development has been effected, will practically equalize the seasonal variations in the flow of the Colorado and will reduce the annual variations. Elimination of annual variations is of primary importance in the conservation of water for irrigation; consequently, there must be provided below the Canyon Section as much irrigation storage as is economical.

There is no clause in the Colorado River Compact which provides for the release in a year of low flow of water for the irrigation of lands below the Canyon Section, although it does provide that during 10 consecutive years a total of 75 000 000 acre-ft. must be allowed to reach Lees Ferry. Consequently, a large amount of hold-over storage must be available to assure the lands in the Lower Basin of a continuous supply of water for irrigation.

The speaker is of the opinion that a reservoir of sufficient capacity for these purposes can be created most economically at Boulder Canyon. For many years it will be possible to release water from Boulder Reservoir in such quantities and at such times as will satisfy both the power and irrigation demands. Ultimately, the release of water from Boulder Reservoir will approach the variable irrigation requirement of the Lower Basin, except as modified by the regulatory effect of a reservoir farther down stream. The power output of other plants along the Colorado would be so modified as to satisfy that part of the power demand not taken care of by the output at Boulder.

Secondary re-regulation of the normal release from Boulder Reservoir should be provided as close as possible to the lands to be served with water for irrigation. As a comparatively small capacity will be required, the best

location, as far as is known at present, would be just below the mouth of Bill Williams River. A dam at this point would also divert water into canals to irrigate large bodies of land between Parker and Yuma, Ariz., and in the Palo Verde Valley. This reservoir would also serve as a settling basin and point of diversion for an additional domestic supply for the cities and towns of Southern California the local water resources of which have been exploited to the safe limit. The value of this reservoir for flood control will be discussed later.

The author has considered that re-regulation can best be effected with a dam at Topock, creating the Mohave Reservoir. The only objection to this site, in his opinion, is that its flowage damages may be high, as it will require moving the Town of Needles, a division point on the Santa Fé Railroad, and re-locating 15 to 20 miles of main-line railroad. He neglected to call attention to the fact that about 100 000 acres of land in the Mohave and Cottonwood Valleys would be submerged and thus eliminated from agricultural development.

The principal advantage claimed for the Mohave Reservoir is based on rather fallacious reasoning. The author states that water for 50 000 acres of land would be saved if Boulder Reservoir were reduced in size and Mohave Reservoir constructed. This assertion is based on apparent differences in evaporation losses.

According to Table 18*, there would be, under the U. S. Bureau of Reclamation plan, an evaporation loss at Boulder Canyon of 650 000 acre-ft. per annum, or 600 000 acre-ft. more than at present, while future evaporation loss, under the author's plan, with the same flood control at Mohave, would be 490 000 acre-ft., from which has been deducted 350 000 acre-ft. as the present loss, leaving only 140 000 acre-ft. as the net loss.

It is incorrect to credit all the present loss from the 72 000 acres of flooded area in Mohave and Cottonwood Valleys to the Mohave Reservoir. Flood control in Boulder Reservoir would greatly reduce the area from which evaporation would occur. This inevitable reduction should properly be credited to the Boulder Reservoir and only the remainder should be a credit to the Mohave Reservoir. Unless submerged, these valleys will be irrigated when regulation is provided, consequently the evaporation from this irrigable area cannot justifiably be deducted from the evaporation loss from the reservoir which would submerge these lands. It would be equally logical to create a reservoir out of the cultivated Palo Verde and Parker Valleys in order to eliminate the evaporation loss from these lands.

In Table 33 is shown the manner in which the speaker believes these losses should be considered. For purposes of comparison, the values in Table 18 are taken as correct.

This saving by the elimination of Mohave Reservoir would be about sufficient to compensate for the evaporation loss from the proposed secondary reservoir near Parker. At least the quantity of irrigation storage given must be provided below the Canyon Section, in addition to that needed for flood

* Proceedings, Am. Soc. C. E., August, 1924, Papers and Discussions, p. 832.

control and for silt accumulation, even if up-river storage is developed later, as considered by the author. Careful analysis of all the factors affecting the reduction of the water supply by evaporation shows clearly the fallacy of this objection to Boulder Reservoir.

TABLE 33.—COMPARISON OF EVAPORATION LOSSES.

	Acre-feet, per annum.
Boulder Reservoir with Maximum Level at Elevation 1,250, Providing 34,000,000 Acre-ft. of Storage, of Which 8,000,000 Acre-ft. are for Flood Control:	
Loss from reservoir surface.....	650,000
Present loss from stream bed.....	..... 50,000
Reduction in flooded area above Topock assumed at only 50% and corresponding reduction in evaporation loss, one-half of 350,000 acre-ft. ....	..... 175,000
 Total.....	 650,000 225,000
Additional evaporation loss under reclamation plan.....	 425,000
 Mohave Reservoir with Maximum Level at Elevation 605, Providing 13,000,000 Acre-ft. of Storage, of Which 8,000,000 Acre-ft. are for Flood Control:	
Loss from reservoir surface.....	490,000
Loss from Boulder Reservoir with storage capacity of 10,000,000 acre-ft., according to author's Plan No. 3.....	340,000
Allowance of 50% of present loss from flooded area within proposed Mohave Reservoir.....	..... 175,000
Present loss from stream bed at Boulder Reservoir (Plan No. 3).....	..... 40,000
 Total.....	 880,000 215,000
Additional evaporation loss under author's plan.....	 615,000
 Net evaporation loss chargeable to Mohave Reservoir.....	 615,000
Net evaporation loss chargeable to Boulder Reservoir.....	425,000
 Difference in favor of Boulder Reservoir.....	 190,000

Flood Control.—The ideal reservoir for flood control would be below the last tributary of any consequence. Unfortunately such a provision on the Colorado River is impossible below the Gila, so that the control of the Gila River floods must be by separate regulating works on that stream. It is generally agreed that reservoirs for flood control on the Colorado should be at, or below, the lower end of the Canyon Section. Consequently, discussion revolves around the selection of Boulder Reservoir or Mohave Reservoir.

There is practically no contributing drainage in the 80 miles along the Colorado River between the Black Canyon dam site and Topock, hence this factor is negligible in the selection of the proper site.

Floods from the drainage area of the Gila River have as great a maximum discharge as floods in the Colorado above their junction at Yuma, but the Gila floods are of short duration. Under present conditions these floods do not tend to coincide, as the Colorado is at its highest stages from May to July, while the Gila floods almost invariably occur during the winter. The former result from melting snow on the mountains in Utah, Colorado, and Wyoming; the latter are from heavy rains in Arizona and New Mexico.

When the Colorado floods are reduced in magnitude by regulation, the flow of the river in the late fall and winter will be increased materially. Provision must be made, therefore, to minimize the probability of a Gila flood being augmented by 40 000 sec-ft. or more from the Colorado.

In this connection, Mohave Reservoir would have an advantage as it is about one day closer to Yuma than Boulder Reservoir. This advantage would be entirely offset if a dam creating the proposed Parker Reservoir were constructed below the mouth of Bill Williams River. Not only would this regulating reservoir be another day closer to Yuma, but it would directly control the flashy floods from the Bill Williams.

When storms were occurring on the head-waters of the Gila River, the normal release from Boulder Reservoir would be curtailed. When it became evident that a flood was imminent on the Gila, the entire flow of the Bill Williams, and that water already released from Boulder Reservoir, could be held back in the Parker Reservoir until the Gila flood had receded. As Parker is closer to Yuma than the last important tributary on the Gila, such a method would be entirely practicable.

The author has resorted to another method of handling the floods of the Colorado River, which does not meet with the approval of engineers long experienced in the actual control of these floods. In order to avoid the possibility of a dangerous coincidence in the flows of the Colorado and of the Gila at Yuma, Colonel Kelly proposes that the stored flood waters shall be released at the rate of about 80 000 sec-ft. By so doing, all flood waters would have been removed from the reservoir before the season for Gila floods. The hydrograph, Plate V,* shows that this would be entirely unnecessary in more than half the years.

As intelligent operation of the flood-control reservoir would practically obviate the coincidence of floods from the Gila and the Colorado, the speaker can see no sound reason for disregarding the opinion of those who have personally been combatting the floods of the Colorado. The engineer of the Palo Verde District has stated—according to the author—that if no levees are provided, the lands of this district would be flooded when the flow exceeds 50 000 sec-ft. and that bank protection is required at floods of more than 35 000 sec-ft. It is the opinion of the engineers of the Yuma Project, that floods of the Colorado should be reduced to 40 000 sec-ft. and that a continuous flow of 80 000 sec-ft. would be almost as hazardous as no control whatsoever. The average flow of the Colorado after regulation is effected will be from 15 000 to 30 000 sec-ft. No channel maintained by such a flow will carry a flood discharge of 80 000 sec-ft. unless both levees and bank protection are provided.

Conclusions.—It is the firm opinion of the speaker that when all factors are taken into consideration, it will be found that the Boulder Canyon Project will most nearly satisfy the physical and hydraulic conditions and at the same time fit in best with existent economic conditions. The U. S. Bureau of Reclamation plan should not be adopted without modification, neither should irrigation be subordinated for power, as would be the case under the plan of development advanced by the author.

* *Proceedings, Am. Soc. C. E., August, 1924, Papers and Discussions, p. 807.*

The speaker has made no reference to the All-American Canal, as he considers that this matter particularly concerns the Imperial Valley and that it should be entirely divorced from the general development of the Colorado River. From the attitude of the Mexican Commissioner at the time the speaker conferred with him as American Commissioner on the allotment of the waters of the Colorado River and of the Rio Grande, it is quite probable that an equitable settlement can be made which will be satisfactory to both Mexico and the United States. Such a treaty should be negotiated as soon as possible.

All efforts should now be concentrated toward the immediate construction of a dam in either Boulder Canyon or Black Canyon that will fit into the ultimate plan of development, while creating for immediate use a reservoir of sufficient capacity for the accumulation of silt, for flood protection, for ample irrigation and domestic supply, and for the development of enough power to satisfy the demand for many years. The selection of the agency or interests which shall effect this construction is a matter entirely foreign to the determination of the proper plan of development of the waters of the Colorado River.

C. S. JARVIS,* M. AM. Soc. C. E. (by letter).†—This paper and the discussions that have followed it are so timely and have done so much toward focusing attention upon the outstanding issues, that the main problems are several steps nearer solution.

One of the important points brought out by the author in regard to the feasible irrigation development is that the ultimate depletion of the water supply due to the use in the Upper Basin will probably never exceed 5 000 000 acre-ft., or approximately 1 acre-ft. per acre supplied. Relating this fact to the apportionment of 7 000 000 acre-ft. to the Upper Basin under the terms of the Colorado River Compact as now drawn, it is apparent that although they may divert the prescribed quantity, the return flow should account for nearly 30%, or 2 000 000 acre-ft. to benefit the lower projects. Also, the return flow from the projects in the Lower Basin and above Hanlon Heading will inure to the benefit of the Imperial Valley and lands in Mexico.

There seems to be no possible challenge to the author's statement of principles regarding the desirable locations for storage, and he plainly concedes that compromises have to be made to suit the natural conditions, such as available sites of sufficient capacity, dependable supply, and prior developments and rights. Inasmuch as the triple interests of irrigation, power projects, and flood protection must be served, it is evident that both upper and lower storage sites must be utilized. Most of these sites near the head-waters have such limited capacity as to be well within the scope of private enterprise.

The investigations of the U. S. Reclamation Service during the past two decades furnish the most definite data yet made available as to comparative values of the various plans suggested. However, they were not extensive enough to determine the actual merits of the principal projects now advocated.

* Associate Highway Bridge Engr., U. S. Bureau of Public Roads, Santa Fé, N. Mex.

† Received by the Secretary, November 13, 1924.

It appears advisable to include an extensive examination of the proposed reservoir basins, especially that which would be utilized by the Boulder Canyon Project, because of the known deposits of rock salt and other soluble minerals which might prove harmful to the lands in the lower deltas. Two of the known salt ridges lie somewhat above the proposed high-water level of the plan advocated by the Reclamation Service; but the extent of the saline deposits within the flooded area should be known in advance.

If some large storage reservoir is provided, such as has been suggested at Glen Canyon, Boulder Canyon, or the Mohave site, then, in order to realize on the power feature during the non-irrigating season, water must be wasted. This would make advisable the provision for auxiliary storage at some point down stream. Thus, the Bulls Head or the Parker site would be among those examined for the purpose of retaining a relatively small storage, from which no primary power would be obtainable.

The conflicting views as to whether the supply of water is greater or less than required by the available irrigable lands, are evidently traceable to varying judgments concerning lands suitable for reclamation.

Field observations made by the writer on the head-waters and in the intermediate valleys of various tributaries justify the opinion that all the feasible sites at the higher levels should be utilized as rapidly as they can be financed. This is particularly true of the Gila River in Arizona, where the direct benefits to irrigation and the incidental reduction of silt burdens and flood menace for the lower delta will be of immense value.

About twenty years ago field data were collected and designs made for the Gila under the direction of Arthur P. Davis, Past-President, Am. Soc. C. E., and others. The use of this material should prevent the delays and controversies over the Colorado River problem which at present seem to be impending.

E. W. LANE,* ASSOC. M. AM. SOC. C. E. (by letter).†—The effect of the deposition of silt on the storage capacity of the proposed basins in the Colorado River has been given careful consideration, but has any study been made of the effect of discharging into the river below the flood-control dam of from 40 000 to 80 000 cu. ft. per sec. of water from which the silt has been removed? It is obvious that the water will pick up and carry away large quantities of silt, and although there is probably little, if any, precedent for determining the quantity thus removed, it is easy to show that this may be important.

The silt now passing the Boulder Dam site is estimated to be 80 000 acre-ft. per year. Neglecting the effect of the redistribution of flow and diversions, if it is assumed that before traveling the 459 miles to the Gulf of California, the stream has picked up as much silt as it is capable of carrying, it would remove practically 80 000 acre-ft. of silt per year. Assuming a river bed 1 500 ft. wide, this quantity would be equivalent to an average depth of nearly 1 ft. per year. It would seem more reasonable to expect it to pick up this in the first 100 miles, in which case, the average lowering would be about 4.5 ft. per year; at the upper end it might be twice this, or more. As the silt percentage

* Asst. Engr., The Dayton Morgan Eng. Co., Pueblo, Colo.

† Received by the Secretary, December 2, 1924.

curve (Fig. 10*) given by the author shows that the silt content was nearly the maximum at a discharge of 40 000 cu. ft. per sec., the redistribution of flow might even increase the silt removal more than 80 000 acre-ft. per year.

The quantity of silt removed from the river bed below the dam will be influenced by a number of factors. As the river bed is cut down, the tributary streams will cut down their beds also, bringing into the main stream large quantities of silt which will reduce the rate of lowering of the main stream bed. The fewer and smaller the tributary streams, therefore, the more rapid will be the lowering of the main stream bed.

If bed-rock lies close to the river bottom or heavy gravel deposits exist, such conditions will retard or limit the erosion in their vicinity, but this will only tend to increase it in other parts of the stream. Diversions of water, of course, will reduce the lowering, by removing the eroding and transporting agent.

The effect of lowering the bed of the Colorado River, down stream from the storage dam, would be in part harmful and in part beneficial. It would lower the tail-water of the power house at the dam; this would give an increase of head, but it might destroy the effectiveness of the draft-tubes, if they were not designed for such a contingency. This effect may also occur at the proposed power dams on the Colorado.

If the lowering is considerable, it will make the diversion of water for irrigation more difficult and may cause serious undermining of the existing dams founded on silt.

Although it is not possible to predict how much effect this lowering will have in improving flood conditions in the lower river, it will at least be beneficial, and may become, in the course of a number of years, an important factor. It is possible that if engineers knew more of the laws governing this action, by preventing the cutting back of the tributaries, and possibly building a retarding basin on the Gila River, to remove the silt from its water also, the river might be made to excavate its own channel deep enough to carry the flood flow without endangering the surrounding country. In his discussion† of the paper entitled "Flood Problems in China", by John R. Freeman, Past-President, Am. Soc. C. E., the writer has already suggested that this method is worthy of study for the improvement of the Yellow River in China, where the conditions are particularly favorable.

RAYMOND A. HILL,‡ Assoc. M. Am. Soc. C. E. (by letter).§—The problem of the Colorado River is too complex for arbitrary solution at this time, as the data which are available, or which might be made available, cannot include certain important factors the determination of which is necessary to the proper solution. The extent of flood control which will be needed after storage is provided, and the quantity of water which will be required for irrigation, are two such indeterminates.

* *Proceedings, Am. Soc. C. E.*, August, 1924, p. 810.

† *Transactions, Am. Soc. C. E.*, Vol. LXXXV (1922), p. 1558.

‡ Associate, Quinton, Code & Hill, Los Angeles, Calif.

§ Received by the Secretary, December 9, 1924.

The author has made use of certain curves showing the relation between the percentage of silt and the discharge of the Colorado River at Yuma, the relation between velocity and discharge, and the area-discharge relation. These curves were originally prepared by the writer in connection with certain studies to determine the relation between silt content and depth for various velocities. Fig. 24 shows the volume of silt which is transported by the Colorado River at various stages when there is no contributing flow from the Gila River.

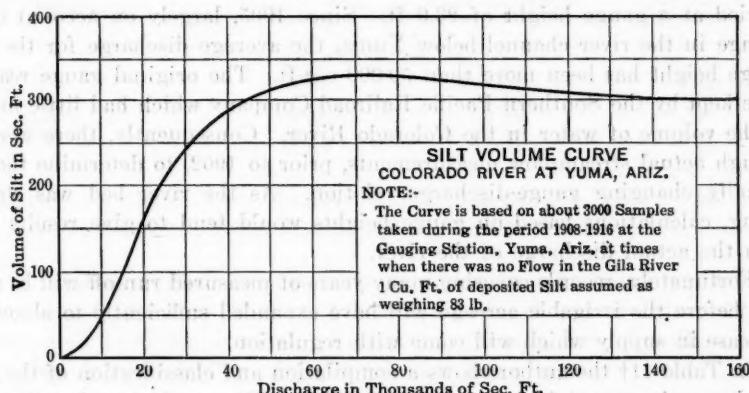


FIG. 24.

It would seem from this that the author is justified theoretically in maintaining that the Colorado River has been more stable at 80 000 sec-ft. than at 40 000 sec-ft. It must be realized, however, that during the years in which these silt measurements were made the river was constantly fluctuating in volume, particularly at the higher stages, and that even with a silt-laden river the proportion of silt would tend to decrease if the discharge were held constant. This in itself would alter the stage of equilibrium. Certainly the characteristics of a desilted river cannot be based on data acquired when the river was heavily laden with silt. Before the Colorado River is regulated, no one can predict which rate of discharge from a flood-control reservoir will produce the most stable condition.

Silt which enters the Colorado River above the last reservoir will be intercepted and deposited in this and other reservoirs. The water which is passed down the river will be clear at first, and it will be highly desirable to keep it as clear as possible by reducing scour in the channel. A load of silt, however, will be picked up along the river whenever the rate of discharge is materially increased. As much of this silt will be carried into the irrigation canals, fluctuations in the flow of the Colorado River should be reduced to a minimum. This consideration alone will require that the release from the flood-control reservoirs be held to much less than 80 000 sec-ft., as the irrigation demand will not exceed about 30 000 sec-ft.

Estimates of the available water supply and of the future irrigation requirements naturally differ widely, as these are to a considerable extent matters of conjecture.

The average annual discharge of the Colorado River at Yuma, as estimated by Herman Stabler, M. Am. Soc. C. E., was 30% greater for the last 20 years than the average for the preceding 20 years. It is believed that the run-off for the years preceding 1902 has been computed too conservatively.

Prior to its break into the Imperial Valley, the Colorado River had been lengthening its old channel by deposition of silt at the head of the Gulf of California. This naturally resulted in a continuous raising of the water surface at Yuma, until, as shown in Fig. 4,* only about 30 000 sec-ft. were carried at a gauge height of 23.0 ft. Since 1905, largely on account of the change in the river channel below Yuma, the average discharge for the same gauge height has been more than 50 000 sec-ft. The original gauge readings were kept by the Southern Pacific Railroad Company which had little interest in the volume of water in the Colorado River. Consequently, there were not enough actual stream-flow measurements, prior to 1902, to determine the continually changing gauge-discharge relation. As the river bed was steadily rising, calculations based on gauge heights would tend to give results lower than the actual discharge of the river.

Fortunately, records covering many years of measured run-off will be available before the irrigable acreage will have expanded sufficiently to absorb the increase in supply which will come with regulation.

In Table 11† the author shows a compilation and classification of the areas which may be served from the Colorado River. His conclusion that the water supply is obviously inadequate depends on the accuracy of the calculations as to the water supply, on the economic feasibility of agriculture on these lands, and on that use of water assumed as necessary.

So much of the area included is less suited to agriculture than other large undeveloped sections in the United States and Mexico, that the writer, who is familiar with the entire area, cannot conceive of its complete development. In 1907, 190 000 acres were irrigated on all the projects of the U. S. Bureau of Reclamation; by 1921, the irrigated area had increased to only 1 250 000 acres, in spite of the fact that natural and economic conditions were favorable to rapid expansion. It has taken 20 years for less than 500 000 acres to be placed in cultivation in the Imperial Valley of California. When it is realized that these areas were the easiest and cheapest to develop, it should be obvious that a great many years must elapse before the irrigated area below the canyon will exceed 2 000 000 acres.

Conservation of water by the reduction of the gross duty will more than offset any further increases in the irrigated area. The author has assumed that 4.2 to 4.5 acre-ft. of water will be consumed each year on every irrigable acre below the canyon. The actual consumption per gross acre of irrigable area in that part of the Imperial Valley served by the Imperial Irrigation District is shown in Table 34, summarized from the 1923 report of the Chief Engineer of that District.

As about 80% of the irrigable area was actually cultivated in the Calexico Division, 70% in the Holtville, 70% in Imperial, 75% in Brawley, East, 70%

* Proceedings, Am. Soc. C. E., August, 1924, Papers and Discussions, p. 805.

† Loc. cit., p. 823.

in Brawley, West, and 45% in the Calipatria Division, the net duty for each acre actually cropped was approximately 2.7 acre-ft. The gross duty for each irrigable acre of a fully developed area will be almost equal to the net duty on each cropped acre, as the transmission losses are generally counterbalanced by the difference between the irrigable and cropped areas.

TABLE 34.—WATER DELIVERY IN IMPERIAL VALLEY, 1923 SEASON.

Division.	Irrigable area, in acres.	Water delivered to farms, in acre-feet.	Acre-feet per gross acre.
Calexico.....	47 000	99 887	2.12
Holtville.....	85 000	154 688	1.82
Imperial.....	130 000	249 630	1.92
Brawley, East.....	78 000	156 188	2.00
Brawley, West.....	82 000	149 933	1.83
Calipatria.....	93 000	109 909	1.18
Total.....	515 000	920 230	1.79

Even without further improvement in irrigation and farm methods, at least 1.5 acre-ft. per acre, or about 5 000 000 acre-ft., should be deducted from the estimated total requirement. Projects comprising several million acres in the San Joaquin Valley of California are being carried forward on the basis of 2.0 acre-ft. per acre, and this quantity is considered sufficient in Southern California. As the character of development progresses, the economic advantages arising from the minimum use of water will force a similar procedure in the Colorado River Basin.

Therefore, it is the writer's firm opinion that future experience will disprove the contention that the water supply from the Colorado River will be insufficient for much of the lands, because he believes that the water supply has been under-estimated, that the economically feasible area has been over-estimated, and, finally, that the available supply can serve a far greater area than that claimed by the author.

E. B. DEBLER, Esq.* (by letter).†—According to the paper, little, if any, saving in the cost of bank protection and maintenance will result from reducing the flood discharge of the Colorado to less than 80 000 sec-ft. Porter J. Preston, M. Am. Soc. C. E., Project Manager and Superintendent of the Yuma Project since 1920, and R. N. Priest, Assoc. M. Am. Soc. C. E., Construction Superintendent since 1903, most of the time in charge of river control work through the Yuma Project, advise that the levees begin to undercut at discharges of 50 000 sec-ft. and that overflow of the natural banks below Yuma begins at discharges of 30 000 to 50 000 sec-ft., depending on river conditions. Colonel Kelly states on the authority of the Engineer of the Palo Verde Project that flooding without levees would begin in the Palo Verde Valley with discharges of 50 000 sec-ft. and that bank protection is required for flows exceeding 35 000 sec-ft. These conditions are typical of all the

* Engr., U. S. Bureau of Reclamation, Denver, Colo.

† Received by the Secretary, December 27, 1924.

valleys below the canyon region. Mr. Preston further states that the channel capacity is increased by 10 000 to 20 000 sec-ft. by scouring of the river bed with continuation of the flood.

Until the Gila River is controlled, levees will have to be maintained to the present levels, but the Gila floods are of such short duration that they do not require bank protection for the levees. The expenditures on levees have largely been for purposes of revetment and this is required by reason of the continued persistent undermining of levees by extended floods originating along the Colorado. In 1913, a levee was cut entirely through with a maximum flood discharge of 62 000 sec-ft. The advantages of reducing all ordinary floods to less than 50 000 sec-ft. are obvious.

Colonel Kelly recommends a flood-storage capacity of 4 000 000 acre-ft. to reduce recorded floods to 75 000 sec-ft. and to permit the interruption of flow for repairs in case of breaks in levees. His floods refer, however, only to the period since 1902. Reliable records indicate a flood in 1884 far in excess of any since 1902, with a maximum discharge for that year at Needles, estimated by Santa Fé railroad engineers on the ground, at 384 000 sec-ft. The maximum discharge at Laguna Dam since 1902 has been 186 000 sec-ft. Herman Stabler,* M. Am. Soc. C. E., estimated the annual discharge for 1884 at 27 200 000 acre-ft. as compared with a discharge of 21 100 000 acre-ft. for 1920 on which Colonel Kelly's recommendation of 4 000 000 acre-ft. of storage is based. The difference of 6 100 000 acre-ft. between the discharges of these two years is largely water that would have to be stored if discharges at Yuma are to be maintained at 75 000 sec-ft. as recommended by Colonel Kelly. The required storage capacity to hold the 1884 flood to 75 000 sec-ft. would then be 10 000 000 acre-ft. compared with 4 000 000 acre-ft. recommended by Colonel Kelly and 8 000 000 acre-ft. proposed by the U. S. Bureau of Reclamation.

The problem of flood control is not one of water alone; it contains an element of possibly even greater importance—silt control. It may be granted that power dams, if constructed on the Colorado River in the immediate future, will cause Colorado River waters to leave the canyon region practically desilted. The present topography of the stream bed and valleys below Boulder Canyon is a balance between the silt supply brought by the stream from upper sources and existing channel conditions. When the silt supply is cut off, this balance is disturbed and the result is entirely beyond the ability of man to forecast with certainty. Will it be safe to turn a continuous stream of 75 000 sec-ft. of comparatively silt-free water into a channel that has adapted itself to heavily silted water? To provide for expected, but wholly uncertain, developments from this change in character of stream flow, liberal allowance must be made for controlling the stream flow to discharges materially less than those proposed by Colonel Kelly.

The paper outlines a permissible development at Mohave Valley in case Congress should deem some provision for flood control and irrigation necessary, and places the cost of the power plant at \$35 per h.p., wholly omitting the cost of transmission lines. Estimates for Boulder Canyon indicate a cost

* *Proceedings, Am. Soc. C. E., August, 1924, Papers and Discussions, p. 817.*

of \$76 per h.p. for the power plant and pressure tunnels with a plant capacity of 200 000 h.p. With the lower head available at Mohave Valley, the cost at that point would be no less. Adding to this amount the estimated cost of \$115 per h.p. for the dam gives a total cost of \$191 per h.p. for a power plant nearly 300 miles from the Southern California market as compared with a similar cost for competitive California sites not only nearer the market, but located so that advantage may be taken of transmission lines already constructed and not fully loaded.

To produce this power the normal flow of the Colorado River must be increased very materially. If, for this discussion, it is admitted that the increase in normal flow caused by the construction of Boulder Canyon Reservoir would be a menace to the fullest possible use of Colorado River waters by reason of an immediate impetus in Mexican irrigation, the Mohave Valley plan for all practical purposes is open to the same objection.

The inability of power revenues at the Mohave Valley site to repay the construction cost is probably best indicated by the fact that this dam site is the only one on the Lower Colorado River that has not been plastered with applications before the Federal Power Commission.

Colonel Kelly states that "all development needed on the Colorado will be built by private capital under adequate Federal and State regulation if the river is given over to development under the Federal Water Power Act". There is little reason to doubt that speedy development can be obtained in this way, along lines, however, as favorable as possible for power but with a minimum regard for irrigation and flood control.

The present status of the Flaming Gorge permit of the Utah Power and Light Company is an excellent example. This permit was originally granted, subject to up-stream irrigation use. It is now understood, however, that the company is reluctant to accept license under these terms and requests irrigation development above the reservoir site to be limited.

The claim that construction of the Boulder Canyon Reservoir will jeopardize up-stream water rights by utilizing the total stream flow applies with equal force to any and all reservoirs and power plans proposed, as even the so-called up-stream reservoirs are below the irrigable areas in the Upper Basin.

Regardless of the amount of storage provided, the flow available for power, whether at Mohave or Diamond Creek, is made up of the normal flow plus a storage increment, the latter alone being affected by the storage capacity provided. The normal flow is of vital interest to power and to irrigation development throughout the basin. Up-stream irrigation development will reduce this plan to the detriment of power development below; it can be safeguarded only by legal and binding agreements which will preclude opposition to such depletion.

In case a plan of private development is adopted, a large development of Colorado River power may come about very quickly in comparison with irrigation development; the provisions for future irrigation development, therefore, must permit wide latitude from any plans that may now be outlined. If inadequate storage capacity is provided for flood control and irrigation before power

developments become crystallized, the bar to full irrigation development becomes insurmountable. The proposal by Colonel Kelly and others to inundate a large irrigable area like the Mohave Valley as the first step in irrigation development requires more justification than has yet been advanced. On the other hand, an excess of storage for irrigation and flood control can be converted later to use for power development, resulting only temporarily in a reduction in power output, provided a market then exists for this added power. Although the Reclamation plan is severely criticized, no alternative plan is outlined in sufficient detail to indicate its comparative value or feasibility.

The author enunciates the generally recognized axiom that power development should be based on up-stream storage. Practical plans usually require some deviation from this principle either to obtain the greatest power output or to obtain a near maximum output at reasonable cost. It is in conformity with this practical application of the principle that the plans outlined in the discussion by Mr. Weymouth* have been evolved.

It is granted that widespread up-stream storage would materially alter these plans, but thus far no agency has proposed such construction and the prospects thereof within a reasonable time limit are decidedly unfavorable. To hold back feasible developments on the Lower Colorado for fear they may not fit in with some theoretical ultimate plan is likely to cause far more loss from delayed development than the possible cost in the far future of reconstruction to fit in with changed conditions. Had the same principle been adopted in the construction of American railroads there would not be a single line from coast to coast to-day.

WILLIAM KELLY,† M. AM. SOC. C. E. (by letter).‡—The writer has been much interested in the discussions by Messrs. Allison, Fowler, La Rue, Davis, Grunsky, Weymouth, Smith, Jarvis, L. C. Hill, R. A. Hill, and E. W. Lane, each of whom has contributed valuable data or opinions on one or more phases of the problem.

The writer will give a brief review of these discussions,§ and close with an expression of his conclusions.

Mr. Allison¶ supports the views expressed in the paper with respect to flood control which, in view of his long connection with Imperial Valley, is very gratifying. He expresses the opinion that there will always be sufficient water for all future irrigation needs and presents data to substantiate this view. Many engineers disagree with him in this respect, but practically all now agree with his further view that power development will precede irrigation development and will materially aid the latter. Mr. Allison's presentation of data on and his discussion of the All-American Canal are valuable contributions, and should prevent the Federal Government from ever taking part in that project.

* *Proceedings*, Am. Soc. C. E., November, 1924, Papers and Discussions, p. 1484.

† Col., Corps of Engrs., U. S. A.; Chf. Engr., Federal Power Comm., Washington, D. C.

‡ Received by the Secretary, November 29, 1924.

§ Mr. Debler's discussion was received too late to be included in the author's review as published herewith.

¶ *Proceedings*, Am. Soc. C. E., November, 1924, Papers and Discussions, p. 1436.

Mr. Fowler* brings out clearly and accurately certain important functions of the Federal Water Power Act and their relation to the Colorado River, which explain the point of view from which the writer has approached the problem. Mr. Fowler's reasoning on the distribution of costs among the various interests instead of inflicting it all on the power consumer, is sound. Finally, he brings out more forcefully than the writer the advantages of a well-balanced progressive development over the single large Boulder Canyon plan.

Mr. La Rue† presents data to show that all the resources of the Colorado will be needed and that probably there will not be enough water to irrigate all the available land. Mr. Allison and certain engineers of the Reclamation Service differ with him in the latter view, whereas Arizona and many engineers who have studied the question agree with him. Nobody can be certain what the future irrigation development will be. It may well be slow as predicted by Mr. Allison, but, considering the vast arid territory through which the river runs, the only safe policy is to see that any project built at present shall involve no ultimate waste of water such as will result from duplicate regulatory storage. Mr. La Rue's recommendations at the end of his discussion have great merit, and are worthy of serious consideration.

Mr. Davis' discussion‡ is a clever composition of facts combined with assertions and partial quotations that misinterpret the writer's views. His arguments appear convincing even to the writer, who knows that many of them are not in accord with the facts. Coming from a man of Mr. Davis' prominence, they will doubtless carry conviction to many. It would be tedious and appear contentious to answer his discussion item by item, but certain additional facts need presentation and certain of his inferences and misinterpretations of the writer's position need correction.

Under the heading "Storage in Upper Basin,"§ Mr. Davis discards the Ouray dam site on account of a railroad right of way granted by the Secretary of the Interior. The right of way in question was granted in January, 1922, for a period of five years to the Denver and Salt Lake Railroad Company on Mr. Davis' recommendation. It lies entirely on the west side of the river, extending from about the middle of Sec. 18, T. 8 S., R. 20 E., to the Town of Randlett, and is all above the 4 800-ft. contour. Information is not available as to where the proposed railroad will cross the Green River, but there seems to be no reason why it should not follow up the river and cross just south of Split Mountain, somewhat on the line of a right of way granted some years ago. This latter right of way has now expired so that the location of the proposed railroad in the vicinity of Green River is still under Federal control. The water surface at the Ouray site is at about Elevation 4 630. Taken in conjunction with Flaming Gorge and Juniper a storage capacity of about 3 000 000 acre-ft. at Ouray will give full regulation of the Green River at the latter point. This capacity can be obtained by a dam 170 ft. high, that is, with a crest at Elevation 4 800 and a draw-down at 25 ft. A dam of about

* *Proceedings, Am. Soc. C. E., November, 1924, p. 1461.*

† *Loc. cit., p. 1468.*

‡ *Loc. cit., p. 1470.*

§ *Loc. cit., p. 1472.*

that height backs the water to the Split Mountain dam site for the development of which there are now two applications before the Federal Power Commission; it is unlikely that a higher dam at Ouray will ever be built. The Salt Lake Railroad may be a desirable development, but should not be a reason for interfering with a proper development of the Ouray dam site.

Although up-river storage cannot be used exclusively for carry-over storage for the Lower Basin to the extent at one time contemplated by the Reclamation Service, it will provide seasonal regulation and can be developed for carry-over storage to whatever extent the future may show to be economically feasible. Mr. Davis states that at least 25 000 000 acre-ft. of storage will be needed in the Colorado Basin. In this figure, he duplicates quantities for flood storage and adds a margin for silt storage, but gives no credit for the silt storage that will be provided by power dams. About 86% of the water reaching Boulder Canyon comes from above Glen Canyon, and considering the possibility of storage dams at Glen Canyon and Cataract Canyon in addition to those higher up, this part of the flow can be completely regulated above Grand Canyon. Such regulation can proceed gradually as economic conditions justify and the extent to which it should be developed can be determined by the economic requirements of the future. It will be relatively free from silt deterioration and will have several times the power value of storage at Boulder Canyon. About one-half the remaining flow is a nearly constant increment requiring no regulation, the remainder occurring in erratic flood flows mainly due to fall and winter rains and rarely exceeding 1 500 000 acre-ft. in any year. These flood flows can be largely regulated and absorbed by the power dams in the Canyon Section and the re-regulating dam below. Such being the case the writer can see no justification for creating 34 000 000 acre-ft. of storage at the bottom of the Canyon Section.

The Reclamation Service estimates indicate that the Big Boulder Canyon project is cheaper for power and storage than any other on the river. This may or may not be the case, but even if it be assumed that it is, the project should not be built unless it is made to conform to a plan of development that will get the fullest use of the water. Colorado River power can be developed cheaper than steam power in Southern California. It will all be needed and nobody should be permitted to "skim the cream," leaving a residue that cannot be used.

Referring to use of up-river storage, Mr. Davis asserts that "This program would be an economic blunder of the first magnitude." His views on economics have often differed from those of the writer, but never more than on this point. It is undoubtedly feasible to regulate the flow of the Colorado above Glen Canyon. The advantage of placing regulatory storage as far upstream as possible is generally recognized, and on no other river known to the writer are the advantages so marked as on the Colorado.

Mr. Davis and most of the Boulder advocates disregard the time element in discussing the Colorado. They compare the initial development of a progressive complete project with the very comprehensive results claimed for Boulder Canyon. If only one development were to be made on the Colorado, their arguments should be given considerable weight, but that is not the case, and

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Mr. Davis himself recognizes that the development of power will proceed rapidly and continuously to its full extent when the present deadlock is broken.

Mr. Davis' statement,* that, "It is certainly better to hold floods by storage, even if part of the water does evaporate, than to let them run to the sea, and fight them en route, as demanded by Colonel Kelly," is the kind of argument advanced by several of the Boulder advocates. The writer has never demanded any such thing; on the contrary, he has endeavored to ascertain what degree of flood protection can be obtained by storage, and has indicated what he believes to be profitable as a first step, with the definite statement that full regulation will be obtained later as power and irrigation development proceeds.

Under the heading, "Mohave Reservoir Wasteful and Destructive,"* Mr. Davis exaggerates all the difficulties and slight all the advantages. The estimate of the Reclamation Service for flowage damages on the Mohave site is \$12 775 000, made up as follows:

Railroad	\$8 500 000
Highway	200 000
General property damage.....	4 075 000

The railroad damages are based on a letter from an official of the railroad company which bears evidence of an intention to play safe. No allowance is made for the elimination of heavy grades on the present approaches to the bridge and the extra operating costs due to the additional three miles of road are capitalized at about \$1 000 000. No allowance is made for salvage on the present division shops, ice plants and other property. On the other hand, the estimate of flowage damages at the Boulder site, the development of which would cause the flooding of many mining claims, two small towns and a branch line railroad terminus, is only \$500 000. Evidently these two estimates are not made on the same basis and are not comparable.

With respect to irrigable land in Mohave Valley, it should be understood that the river meanders through this Valley in such a way that under present conditions the cost of reclaiming the land by holding the river in place is too great to make the land of any value. What the conditions will be when the river is controlled to a maximum flow of 40 000 cu. ft. per sec., as proposed by the Reclamation Service, is problematical. It should be less expensive to reclaim the land under those conditions, but levees and bank protection will still be necessary, and will cost at least \$50 000 per mile. The land is divided by the river into five tracts, as shown in Table 34.

To the cost of reclamation must be added the cost of irrigation and drainage, which will probably be not less than \$75 per acre. To the usual operating costs must be added a figure for maintenance of levees and bank protection. Considering these facts, none of this land is economically feasible for irrigation, with the possible exception of the tract at the south end of the Valley. A dam at Parker of the height proposed by Mr. Davis would submerge this tract; a dam at Parker that does not submerge this tract will not materially interfere with a dam at Mohave.

* *Proceedings, Am. Soc. C. E., November, 1924, Papers and Discussions, p. 1474.*

TABLE 34.—IRRIGABLE LANDS, COTTONWOOD AND MOHAVE VALLEYS.
(Acreages from Unpublished Report of Reclamation Service, 1916.
Other Figures Compiled by the Writer.)

Tract.	AREA, IN ACRES.						Miles of revetment and levee.	Estimated cost per acre of levee and revetment.	Remarks.			
	Irrigable.		Waste.		Total.							
	Gravity	Pump.	Gravity	Pump.	Gravity	Pump.						
Cottonwood Valley:												
East side.....	2 085	.....	1 551	.....	3 636	.....	5	\$125.00	.....		
West side.....	2 214	.....	703	.....	2 917	.....	7	160.00	.....		
Mohave Valley:												
Arizona side.....	.....	700	2 200	400	2 200	1 100	..	.....	All gravity land has been ruined by meanderings of river.
Opposite from Mohave.....	1 000	70	4 800	230	5 800	300	10	500.00	.....		
Arizona side.....	22 500	2 425	12 500	1 200	35 000	3 825	28	56.00	.....		

Mr. Davis states that engineers who examined the Mohave site twenty years ago rejected it. It may be well to record why this site was then rejected. The flooding of the railroad, of the Town of Needles, and of 40 000 acres of supposedly irrigable land was believed to be involved in developing a reservoir capacity limited to 1 500 000 acre-ft. On these premises, it was concluded.*

"In view of the existence of several reservoir sites below and of the damage which would occur from the construction of a dam at Blue Canyon (Mohave Canyon), it is believed that this valley near Needles (Mohave Valley) can be more profitably utilized by irrigation from diversion canals (than as a reservoir)."

If the premises were correct one could easily agree with the conclusion, which, as it should be, was based on the greatest measure of profit to be obtained from the resources involved. It was not reported as "infeasible" despite Mr. Davis' statement† that it was "unanimously regarded as infeasible." For a reservoir, the Valley is unusually well shaped; the floor is quite flat and the banks rise steeply from it so that it can be used without creating much shallow water. With a dam 180 ft. high reserving 4 000 000 acre-ft. for flood control, the depth of water at the upper end of Mohave Valley at maximum draw-down would be about 90 ft., and at the upper end of Cottonwood Valley about 40 ft. This cannot properly be termed a shallow reservoir.

Under the heading, "Wanton Destruction of Valuable Storage,"† Mr. Davis argues that storage at Boulder Canyon must be reserved for silt. On the basis of 100 000 acre-ft. of silt per year, the smaller Boulder Canyon Dam suggested by the writer would hold the entire deposit for a period of 100 years. The power dams above would hold at least as much more. No sufficient study of the silt problem has yet been made; probably storage will always be

* First Annual Report, U. S. Reclamation Service, pp. 113 and 114.

† Proceedings, Am. Soc. C. E., November, 1924, Papers and Discussions, p. 1475.

the cheapest way of taking care of this. If the silt problem were to control, no dam above Boulder Canyon should be built until Boulder Reservoir had filled to the maximum for comfortable operation. Then the next dam up stream should be built and allowed to fill, and so on. Such a program would run over a period of several hundred years and would be intolerable. Although silt will add to the expense of using Colorado water for domestic, irrigation, and power purposes, it will not prevent that use provided sufficient storage can be maintained to regulate the flow. As nearly all the silt enters the river below the San Juan, storage above that point will be little affected. Ultimately, at least in theory, all storage below the origin of silt will fill, and the only regulation of flow will be that which can be obtained above that origin. The silt problem is a strong argument for seeking regulatory storage above the San Juan, but not for excessive storage at Boulder Canyon. It is quite certain that complete desilting at Boulder will greatly accentuate the ever-present tendency to erode banks and to pick up a heavy load of silt from the vast quantities now stored in the bottoms along the 300 miles between that point and Yuma.

Under the heading, "Proper Plan of Development,"* it is encouraging to note that Mr. Davis gives consideration to adapting his Boulder Canyon project to a full development of the lower river. Perhaps he will eventually come to consider also the upper river and to give proper weight to the regulatory storage that can and will be provided there. The only regulatory storage needed in the lower river in the final development is in the lowest reservoir that will give sufficient storage, so that no power will be lost owing to the difference in the power and irrigation demands. Mr. Davis' discussion makes it necessary for the writer to point out again that he is not committed to his plan, and that it was used simply as an illustration. A better plan can doubtless be developed when the necessary data are available.

In discussing "Poor Rock in Glen Canyon,"† Mr. Davis emphasizes the writer's presumption in differing with his eminent Board. The writer questions whether there is much difference between his own views and those of the Board regarding the quality of rock at Glen Canyon. The report of the Board which examined this site was signed by Messrs. F. E. Weymouth, F. L. Ransome, L. C. Hill, and A. J. Wiley (three engineers and a geologist), on December 20, 1922. The following is quoted from the report:

"11. The Jurassic sandstone has been fully described by Gregory, Bryan, and others. It is a fine-grained, very uniform quartzose sandstone which appears to owe its reddish tint to the superficial redness of certain individual grains. The grains are imperfectly cemented and the whole resembles in hardness the type of soft brick known to the trade as salmon brick. It crumbles under shock, such as that of ordinary blasting, and small fragments can be crushed to sand between the fingers. Notwithstanding its softness the rock stands remarkably well in the canyon walls, forming large, smooth cliffs that rise for 1,000 ft. or more above the river, and which in places are within 5° of being vertical.

* * * * *

* Proceedings, Am. Soc. C. E., November, 1924, Papers and Discussions, p. 1476.

† Loc. cit., p. 1478.

"13. As pointed out by Dr. Bryan the Jurassic sandstone is too soft and too easily broken on corners and edges to make good building stone, and is entirely unsuitable for use as concrete constituent. In large masses, however, it successfully resists the weight of the towering canyon walls and shows no signs of failure at the base of the cliffs where these come down to the water's edge. Under the atmospheric conditions prevailing at the canyon, moreover, the sandstone in spite of its softness withstands the action of the weather remarkably well. Some of the smooth walls must have stood without appreciable change for centuries.

* * * * *

"30. The abutments for a gravity type concrete dam are fully exposed, and the foundation is indicated by a diamond drill boring. Both are of a quite uniform soft sandstone which is not hard enough for a building stone, but probably will be found to have sufficient strength to support a concrete dam."

As far as the writer can ascertain, no other Board report on the subject has been made, but apparently one member of the Board expressed somewhat modified views about a year later, for Mr. Weymouth, in his report of February, 1924, quotes from a letter of November 27, 1923, by Mr. Wiley as follows:

"It does not seem feasible to build any type of masonry dam of the necessary height for effective storage on the soft sandstone at Glen Canyon, at least no type or height requiring maximum pressures of more than 20 tons per square foot should be used."

Two years ago the writer spent four days examining this dam site. Evidence of bearing power is furnished by the cliffs which rise nearly vertical to a height of 1,000 to 1,500 ft. It may be well to point out that bearing power is determined by compactness, rather than by hardness and that the rock in question leaves nothing to be desired in the way of compactness. The cementing material is not strong enough to resist heavy erosion; spillway and power tunnels would have to be lined, but in foundations, even with the most ordinary precautions to prevent failure by displacement, the rock will certainly bear more than the load which it is safe to place on concrete in a dam.

It may be interesting to note that common practice considered the safe maximum stress in concrete dams as 20 tons per sq. ft., until some of the high dams of the Reclamation Service were built, when it was found that the cost of maintaining that standard was prohibitive, and the limit was raised to 30 tons per sq. ft. The same experience resulted from the design of the high Boulder Dam; Mr. Davis and his Board of Engineers have designed that dam with a maximum stress of 40 tons per sq. ft., equivalent to 555 lb. per sq. in. The concrete will have to be unusually good to insure an ultimate strength of 2,000 lb. per sq. in. In other words, the factor of safety will be about 3.6 in the concrete. The loading assumptions used by the designers are conservative, but with the tremendous loads available for unexpected concentration in such a high dam, there is a risk in so far exceeding precedent which nothing but positive necessity can justify.

The economic height for power dams in the Canyon Section can be shown to lie between 200 and 400 ft. Dams higher than 400 ft. can be justified only for storage or, perhaps, for the purpose of backing the water up to the next feasible dam site, and should not be permitted unless it can be positively proved

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that the full development of the river cannot be obtained without them. The writer does not consider it necessary or desirable to build a very high dam at Glen Canyon—probably not over 400 ft., and certainly not over 500 ft.

Referring to the heading, "Increase of Low-Water Flow,"* legal views of eminent authorities are available to prove that Mexico can never profit from the storage of water in the United States, but any one who will study the history of the relations of the United States with other countries, especially with those of the American Continent, will realize that the United States always sets aside legal arguments and settles on a basis of unreasonable liberality. It is certainly a wise precaution to obtain a treaty with Mexico to cover the question. Fortunately, conditions seem favorable at present for negotiating such a treaty and it is understood that preliminary steps are already under way.

Mr. Davis makes two statements in his discussion which cannot be overlooked. In the first he says,† "This emphasizes the real point at issue, that is, whether the immense resources of the Lower Colorado are to be retained in the control of the Federal Government or turned over to private corporations." Any one familiar with the Federal Water Power Act knows that it sets forth a complete Federal control—the product of more than twelve years' consideration by Congress. Nobody, as far as the writer is informed, has ever proposed less Federal control except certain advocates of municipal development who do not wish to be burdened by the Federal Water Power Act, and who have called forth the private monopoly specter in their efforts to obtain special privileges for themselves.

The other point is where Mr. Davis states:‡

"The author deserves thanks for the frank official declaration of the settled policy of the Federal Power Commission, in his statement that: 'All the development needed on the Colorado will be built by private capital under adequate Federal and State regulation if the river is given over to development under the Federal Water Power Act'".

The writer made a simple statement of fact to indicate that no appropriation by Congress is necessary to procure a full and economical development of the Colorado River. In another part of his discussion,§ Mr. Davis confirms this, but he proceeds to construe the writer's plain statement of fact into a declaration of the policy of the Federal Power Commission. The policy of the Federal Power Commission with respect to any pertinent subject can always be obtained by application to the Commission or can be deduced from the precedents set up during the past four years. The Commission has administered the Act strictly in accordance with its terms, and all municipal applications have received the preference to which the law entitled them. The only municipal application for power development on the Colorado River is that made by the City of Los Angeles for the Boulder site. The City made it clear to the Commission that it did not wish consideration of its application unless Congress definitely refused to appropriate for the Boulder project. Judging by precedent, the City of Los Angeles can feel assured that it will get all the preference

* *Proceedings, Am. Soc. C. E., November, 1924, Papers and Discussions, p. 1479.*

† *Loc. cit., p. 1475.*

‡ *Loc. cit., p. 1481.*

§ *Loc. cit., p. 1474.*

contemplated by law if and when any application for the Boulder Canyon Section of the river is considered by the Commission. Mr. Davis' statement is an accusation that the members of the Commission have acted in defiance of the law entrusted to their administration. Such an accusation has no place in an engineering discussion. It may be noted that a similar accusation has been made recently by certain municipal ownership advocates who claim that the Commission is not carrying out the law because it has subjected their projects to the same examination as private projects and has not granted the applications "sight unseen". Mr. Davis seems to be convinced that opposition to his project is due entirely to objection to public ownership. That is not the case; the writer's opposition is and always has been based solely on engineering and economic grounds.

Mr. Grunsky* emphasizes the need for a treaty with Mexico. He also discusses the division of the resources of the Colorado among the various States and proposes, as a solution, Federal control. The tendency to mould economic laws to fit political boundaries has always been prevalent; it probably will never be entirely overcome, although it is dangerous and has been responsible for most of Europe's troubles. All the developments on the Colorado thus far proposed involve power and occupy public lands, and, therefore, in the absence of new legislation, will come under the Federal Water Power Act, which provides a Federal control that is adequate. The Act does not provide Federal funds for construction, nor does it give the upper States a treaty guaranty of water rights, but, judging by experience under the Act to date, it will give them all the protection they need.

With reference to Mr. Weymouth's discussion,† the writer had no intention of misquoting or misrepresenting the data presented by the Reclamation Service. Table 11‡ does not purport to be taken from any report of the Bureau of Reclamation. It is quoted from a report by Herman Stabler, M. Am. Soc. C. E., and is a compilation of data made available to him by Mr. Weymouth. Evidently the same data, slightly modified, were compiled in Table 30 by Mr. Weymouth in the report to which he refers. The essential differences between the two tables are explained in the footnotes to Table 11.§ The text of the footnotes is based on statements in the report made by Mr. Weymouth in February, 1924.

In Table 19,|| the term "Bureau of Reclamation Plan" was used in a general sense as referring to a high dam at Boulder Canyon, and the data used in the table were computed by the writer. There should be no misunderstanding on this point because all the figures are based on up-river regulation which Mr. Weymouth and the Reclamation Service have declined up to the present to consider as available. Mr. Weymouth cites the historical develop-

* *Proceedings, Am. Soc. C. E., November, 1924, Papers and Discussions, p. 1481.*

† *Loc. cit., p. 1484.*

‡ *Loc. cit., August, 1924, p. 823.*

§ These footnotes are erroneously indicated on page 823, the August, 1924, *Proceedings*. The asterisk should be placed against 870 in Column 8 instead of 200 in Column 7, and the dagger should be placed against 200 in Column 8 instead of against 1400 in Column 7.

|| *Proceedings, Am. Soc. C. E., August, 1924, Papers and Discussions, p. 833.*

ment of the investigation conducted under his direction. Conditions have changed materially since this investigation was commenced. Mr. Weymouth's willingness to consider an ultimate plan of development as evinced in February, 1924, together with the general trend of his discussion, might be taken as an indication that if he had continued in charge of the investigation he might have spread it sufficiently to get the broader scope which the writer deems necessary. About the only material difference between his views and those of the writer is in regard to the feasibility of storage elsewhere than at Boulder Canyon. The data available on storage sites may be sufficient to have convinced Mr. Weymouth that up-river regulation is infeasible, but it has failed to convince many others, including the writer.

Professor Smith* points out the interests of the State of Arizona in the Colorado River. These interests have been fully recognized by all Federal authorities. Unfortunately, there is divided opinion in Arizona as to what should be done with its interests so that much delay in getting started on any project for the Colorado is likely to result. Professor Smith discusses the question of water rights. The writer does not pose as an expert on that subject, but whatever the law may be it is certain that representatives of the upper States have persistently refused to accept anything short of an interstate treaty as protection of their future needs. Professor Smith's suggestion that the matter be settled by the Imperial Valley suing the permittees on Flaming Gorge does not seem to be practicable, because Flaming Gorge cannot in any way infringe on the rights, present or future, of the Imperial Valley, and there is no ground on which to base a suit. Professor Smith's suggestions with respect to up-river storage are sound, but as yet, no one has shown a practical way of financing a dam at Dewey in advance of a certain amount of power development below. Professor Smith might with justice point out that the same objection exists against the Mohave site. The Federal Government has considered such projects only in connection with the improvement of navigation or under the terms of the Reclamation Act. It is stretching the point rather far to consider that Boulder Canyon or a substitute comes under either category, and it is doubtful if Congress will set a new precedent by undertaking any project on the Colorado unless there is a strong public demand and practically no opposition.

The people who might be expected to support a proposition for a flood-control dam at Dewey are supporting Boulder Canyon and opposing everything else. Under the circumstances, the only prospect for early development of up-river storage appears to the writer to be in connection with power development.

Mr. Jarvis' discussion† comprises a brief résumé of the Colorado problem and expresses his views on certain phases of the problem.

Mr. L. C. Hill discusses‡ the Glen Canyon site as a power site. The writer has never considered such a development probable. If the Glen Canyon Dam is built it will probably be as a storage dam to regulate the flow for projects

* Loc. cit., November, 1924, p. 1492.

† See p. 268.

‡ See p. 262.

lower down. Eventually, it might be feasible to develop power at Glen Canyon, but that is hardly likely to be economical in the early stages. Mr. Hill seems to appreciate the desirability of making all the units fit into a plan for full development. He misunderstands, however, the writer's views with respect to the relation between power and irrigation, namely, that power development will proceed more rapidly than irrigation but not that power should be allowed to curtail irrigation. On the contrary, construction at power sites can and should progress so that it will permit and aid the fullest practicable irrigation development. The writer does not agree with Mr. Hill that storage for annual hold-over will be necessary or advisable at Boulder Canyon.

Mr. Hill states that about 100 000 acres in Mohave and Cottonwood Valleys would be submerged by a dam near Needles. The total area submerged by the highest dam proposed will be about 75 000 acres and, as shown under the writer's reply to Mr. Davis' discussion, of this less than 25 000 acres can ever be irrigated.

In regard to Mr. Hill's computations on evaporation losses in Mohave Valley, it is difficult to determine with any certainty what conditions will be if the flow is regulated to a maximum of 40 000 cu. ft. per sec. The writer's estimate of present evaporation losses is based on the area overflowed by a river stage 10 ft. on Topoc gauge. This stage has been reached in the past few years with flows varying from 35 000 to 60 000 cu. ft. per sec. The writer believes there will be no material reduction in evaporation losses with the flow regulated to 40 000 cu. ft. per sec. Of course, if any of the overflowed area is reclaimed and put to beneficial use, it should be deducted from the area producing present evaporation losses. Under the most optimistic estimates not more than one-third of the overflowed area will warrant the cost of reclamation; the writer does not believe that any of it will.

In regard to flood protection, Mr. Hill's principal argument is that the writer disregards the opinion of those who have personally been combatting the floods of the Colorado. This is not the case—it was because the writer found considerable difference of opinion among those who have been combatting the floods that he deemed it advisable to make a careful study of the situation. That study is presented in the paper. The facts have been approved by the Reclamation Service engineers, to whose opinions Mr. Hill doubtless refers, and the writer has found no reason to change his conclusions.

The writer regrets that he did not specifically acknowledge the use of the data prepared by Mr. R. A. Hill.* It was obtained from the Bureau of Reclamation, together with much other data, and so was acknowledged *en masse* as the work of that Bureau.

The writer agrees that it will be desirable eventually to equalize the flow of the river as far as practicable, but he also believes that the partial equalization set forth in his paper is sufficient to remove the flood menace and that until certain other matters are arranged, such as a treaty with Mexico and flood control on the Gila, no greater equalization is advisable.

* See p. 271.

The question has already been discussed as to whether the water supply from the Colorado is sufficient to meet all future irrigation needs, and the writer will do no more than reiterate his statement that in such a vast arid region, whatever present expectations may be, it is certainly prudent to avoid all unnecessary waste of water.

Mr. Lane* raises the interesting question as to what results will follow the release of practically clear water into the silt-filled valley below the Canyon Section of the river. There are so many unknown factors in the problem that, as he points out, no one can predict results with certainty. It can hardly be doubted, however, that the river will pick up a new load of silt in a relatively short distance below the dam. Until it has acquired its new load, there will doubtless be an increase in the tendency to meander through the wider stretches of the valley, combined with a tendency to lower the bed of the stream, and these actions may affect the equilibrium of the stream all the way to its mouth.

H. T. Cory, M. Am. Soc. C. E., has discussed† the effect of Laguna Dam, which had a capacity for storing about 20 000 acre-ft. when it was first completed in 1909. Unfortunately, the effect of this silt storage was largely obscured by the effect of change in river conditions below. The river dropped out of its old channel into Bee River and Volcano Lake in 1909 and the lowering of the bed due thereto was probably greater than that due to the clearing of the water.

These conclusions may be summarized, as follows:

During the past four years as Chief Engineer of the Federal Power Commission, the writer's time has been largely devoted to examining applications for water-power projects to see that "the plans for same * * * shall be such as in the judgment of the Commission will be best adapted to a comprehensive scheme of improvement and utilization for the purposes of navigation, of water-power development, and of other beneficial public uses." As planned by its advocates, the Boulder Canyon project, with its 605-ft. dam, does not, in his opinion, meet this requirement. Additional field investigations of dam sites immediately above and below Boulder Canyon are necessary to determine with certainty the extent to which the Boulder Canyon project should be modified to make it fit into the best plan of development.

The recent re-election of Governor Hunt, of Arizona, on a platform definitely opposing the Colorado River Compact indicates that early ratification of that Compact is unlikely. The most active proponents of the Boulder project are primarily interested in securing a large block of power. The project proposed has the physical capacity for appropriating and using more water than the Compact allots to the Lower Basin. Its advocates are not willing to curtail the capacity, and their proposals for legislative limitation have been rejected by the representatives of the upper States. Consequently, in the absence of the Compact the prospects of a compromise between advocates of the Boulder Canyon project and the upper State interests do not look promising. It seems highly desirable to make the most of this probable delay

* See p. 269.

† *Transactions, Am. Soc. C. E.*, Vol. LXXVI (1913), p. 1204.

by completing the field investigations needed and by negotiating a treaty with Mexico.

It is regrettable that the beginning of development on the Colorado should face such a delay, and the writer has given much thought to ways and means of avoiding it. It would seem that the upper States would have no logical ground for objection to any project that is designed and carried out on plans that would prevent the appropriation and use of more water than is allotted to the Lower Basin by the Compact. The Mohave Valley site was suggested as a flood-protection project on this basis. Perhaps the Dewey, combined with some other up-stream reservoir, would serve as well. To date, however, the interests needing flood protection have shown no disposition to look for any solution other than Boulder Canyon.

The Flaming Gorge and Diamond Creek projects are both desirable. Neither will conflict in any way with the terms of the proposed Compact. Although they will not, in themselves, greatly benefit the Lower Basin, they constitute a first step toward the ultimate complete development of the river. Both are authorized under preliminary permits issued by the Federal Power Commission; they will ask for licenses to begin construction in the near future. It is some time since the Federal Power Commission has given these projects consideration, and the writer cannot predict what action it will take, but all things considered, it appears that they offer perhaps the most favorable opportunity for a start on developing the Colorado.

SECONDARY STRESSES IN BRIDGES

Discussion*

By MESSRS. H. M. MACKAY, GEORGE E. BEGGS, D. B. STEINMAN, AND THOMAS C. SHEDD.

H. M. MACKAY,† M. AM. Soc. C. E.—The speaker considers this paper the most useful treatise on secondary stresses that has yet been published. The various methods of calculation are so clearly explained and so frankly compared that the reader can easily choose for himself the one best suited to his problem. It is not, however, the speaker's purpose to discuss the paper, but to deal with another phase of the question. Given the fundamental assumptions, the theory of secondary stress calculations may be regarded as well established; but there is still some doubt as to the extent to which the assumptions are valid and to which actual stresses agree with those calculated.

In all the methods of calculation explained in the paper two assumptions are tacitly made:

1.—That the members meeting at a joint are so rigidly held that the angles between their axes at the extreme ends remain constant.

2.—That between its extreme ends each member is quite free to bend and that its moment of inertia remains constant.

The first of these assumptions is dependent on the relative rigidity of the gusset-plates, connecting rivets, and members themselves. Relative rotation of the ends of members may sometimes occur. This, of course, would reduce the secondary stresses. The second assumption is never true in riveted frames. The members are under a measure of restraint, or, to put it differently, have an increased moment of inertia for some distance from their ends. This tends to increase the secondary stresses. Many other factors affect the stresses at critical sections, so that although a number of valuable measurements have been made, present knowledge of actual stresses is far from complete, and any addition to the slowly accumulating data may be pertinent.

In the course of an examination of some 104 ft. 7-in., Pony truss spans for a Canadian railway (Fig. 97), the speaker made a fairly thorough survey of one-half of one truss, with a 10-in. Howard gauge, for the purpose of ascertaining the maximum stresses under a heavy type of Mikado engine then recently put into service. Gauge points were first established as close as possible to the ends of the members selected for examination. From eight to ten gauge lines were placed at each section as shown in Fig. 97, and their

* Discussion on the paper by Cecil Vivian von Abo, Jun. Am. Soc. C. E., continued from January, 1925, *Proceedings*.

† Dean, Faculty of Applied Science, McGill Univ., Montreal, Que., Canada.

lengths measured with the span unloaded. A test train consisting of a 225-ton Mikado engine followed by two 50-ton coal cars fully loaded (Fig. 97) was then placed on the span in such a position as to give the maximum stress in the central section of the top chord, which was the principal source of apprehension. The stresses in the other important members for this position of the load were, however, not far below the maximum. The established gauge lengths were again measured and the stresses due to the static live load thus determined. Afterward, impact tests were carried out, using recording deflectometers and extensometers, but these do not concern this discussion.

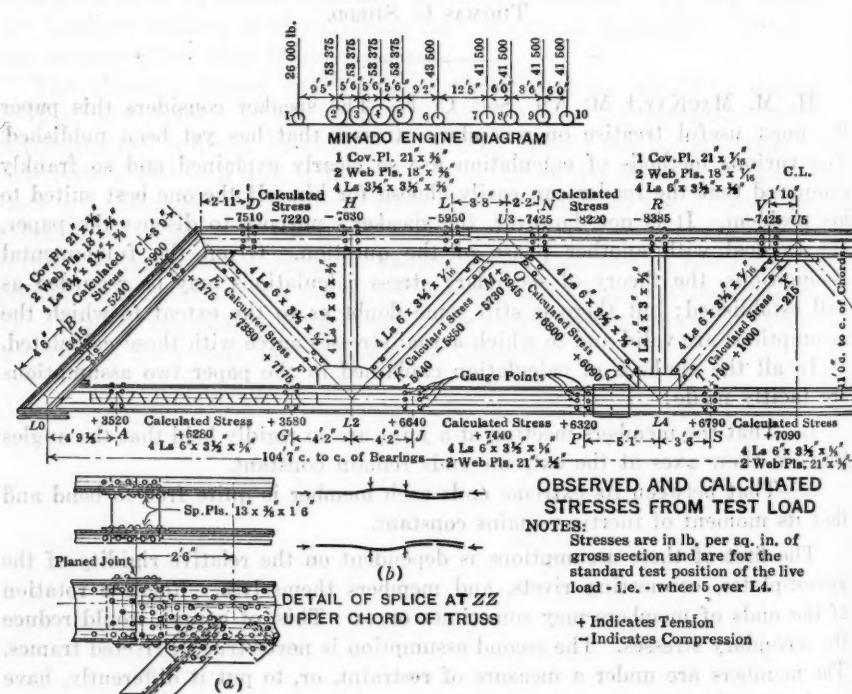


FIG. 97

Although these impact measurements brought out nothing new, they confirmed very well the principal conclusions reached by the Committee on Impact of the American Railway Engineering Association.

The speaker believes that the method here described whereby the measurement of static and dynamic effects is made separately, has much to commend it. The determination of the highest stresses existing at critical sections required the use of short gauge lengths. It is desirable to have numerous points of measurement across the section, since a planar variation of stress is a purely imaginary condition in most built-up members. Even if the recording and other extensometers and gauges available for measuring dynamic effects were entirely reliable (which is perhaps not yet fully established), it

is hardly practicable to use them with such short gauge lengths, and in such numbers, simultaneously, as to give satisfactory results. On the other hand, considerable time and expense are involved in making a number of consecutive measurements by shifting the instruments and running the test train over the span repeatedly for each member measured; and it is impossible to ensure the duplication of the same conditions under repeated runs. Measurements of static stress can be made quickly, inexpensively, and, above all, reliably. A comparatively small number of determinations of the dynamic effects at convenient points will then give all the data required. The speaker would strongly urge that at least some check measurements of static stress should be made a part of every program for stress determinations in bridges. He believes that this procedure would prevent the accumulation of much data of doubtful accuracy which may cloud rather than throw light on the questions at issue.

The static live load primary stresses as calculated, and as measured, taking E as 29 000 000 lb. per sq. in., are shown on Fig. 97. The average differences between the measured stresses at the two ends of the same member were, as follows:

Bottom chords, 190 lb. per sq. in., or 3.6% of stresses measured.

Web members, 145 lb. per sq. in., or 2.3% of stresses measured.

Top chords, 840 lb. per sq. in., or 12% of stresses measured.

At the point, L , in the top chord, the stress, although the measurements were repeated and carefully checked, was abnormally low. The section of measurement was at the end of a splice plate as shown in Fig. 97(a), and it is suggested that the webs and flanges of the angles may have been affected as in Fig. 97(b). If the webs were thus bent (the angle flanges would probably be similarly affected), the fact that the gauge measurements were taken on the convex side of the bend would account for the low stresses observed. Doubtless, similar effects would occur in some degree at other points. The speaker has often noted effects of this kind in extensometer work.

Comparing the measured and calculated stresses, it appears that in the bottom chords all the measured stresses were less than those calculated. The average difference was 1530 lb. per sq. in., or 22% of the calculated stress. The difference was greatest in the end section, 2930 lb. per sq. in., and least in the center section, 300 lb. per sq. in. In the web members, too, all the measured stresses were less, the average difference between calculated and measured stresses being 310 lb. per sq. in., or 5% of the average measured stress. In the top chords and end post, the measured stress was in some cases greater and in some cases less, the average difference being 570 lb. per sq. in., or 8% of the average measured stress. The mean measured stress in these members was, however, only 145 lb. per sq. in., or 2% less than the mean calculated stress.

In explanation of the great discrepancy between the observed and calculated stresses in the bottom chord, it is to be noted:

- 1.—That the roller bearings were inoperative.

2.—That four lines of stringers were used, the outer line being about 3 ft. 2 in. from the ends of the floor-beams.

3.—That the floor-beams were provided with 15 in. by $\frac{1}{2}$ -in. cover-plates extending about 10 in. beyond the outer line of stringers. The floor-beams were, therefore, unusually rigid laterally. Analysis of the conditions thus set up hardly seems worth while, particularly in view of the character of the end connections of the end floor-beams. Qualitatively, however, they explain reasonably the observed stresses existing in the bottom chords. Discrepancies elsewhere may be attributed partly to local conditions, partly to uncertainties regarding the distribution of wheel loads, and partly to errors of measurement.

In calculating the secondary stresses the following adjustments were made:

1.—Measured primary stresses were used in preference to those calculated where there was a material difference between them.

2.—Inasmuch as the observed deflection at the center of the span was only 94% of that calculated on the basis of the measured stresses, all primary stresses were reduced 6% for the purpose of computing angular distortions. This it was hoped would make a reasonable allowance for the effect of details and end connections in diminishing the axial distortion of the members.

3.—Although the stresses in the verticals were not measured, the Howard gauge being unsuitable for measuring small stresses, an estimate of these stresses was made by considering the deflection produced in the top chords, and the values thus obtained, amounting to a few hundred pounds per square inch, were inserted.

4.—The end of the span rested on hardwood blocking without any hinge. An approximate analysis showed that, as might be expected, there was no close approach to fixity at this joint. In the absence at the time of any suitable means for measuring the rotation of the joint, it was impossible to calculate independently the value of the external moment. The speaker, therefore, "loaded the dice" to a certain extent by introducing the value of this moment derived from the measured secondary stresses in the adjacent members. The measured secondary stresses at this point are, therefore, in no way a check on the calculated values, except as regards the relative bending moments in the two members meeting there.

The calculated and observed stresses are shown in Figs. 98 and 99 on which the observed stresses at all gauge points are plotted on an elevation of the member. The full inclined lines drawn across the diagrams show the average measured primary stress plus the calculated secondary stress; the broken lines show the calculated primary plus the secondary stress. In Fig. 100, the calculated and observed bending moments for the chord members are shown. The "observed bending moments" were deduced solely from the measured stresses in fibers near the upper and lower edges of the members, all intermediate measurements being neglected for this purpose.

Figs. 98 and 99 show that in most cases the agreement between the calculated secondary stresses is very good. A notable exception is the point *D*, (Fig. 98) near the end of the top chord, which, according to calculations based on the usual assumptions, would be close to a point of inflection.

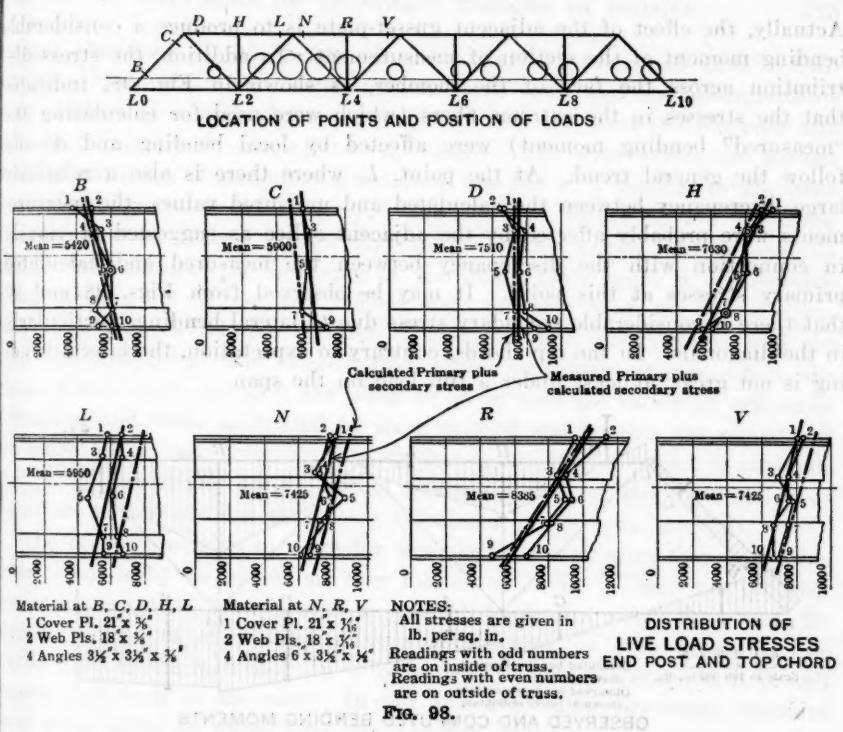


FIG. 98.

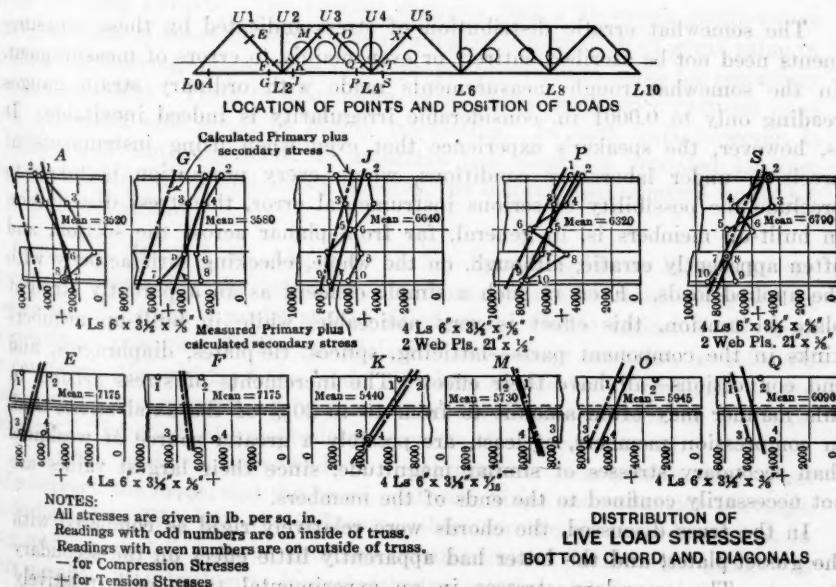


FIG. 99.

Actually, the effect of the adjacent gusset-plate is to produce a considerable bending moment at the section of measurement. In addition, the stress distribution across the face of the member, as shown in Fig. 98, indicates that the stresses in the extreme fibers (which were used for calculating the "measured" bending moment) were affected by local bending and do not follow the general trend. At the point, L , where there is also a relatively large discrepancy between the calculated and measured values, the measurements were probably affected by the adjacent splice as suggested previously in connection with the discrepancy between the measured and calculated primary stresses at this point. It may be observed from Figs. 98 and 99 that there is considerable secondary stress due to lateral bending, particularly in the diagonals. In the top chords, contrary to expectation, the lateral bending is not great, at least under a full load on the span.

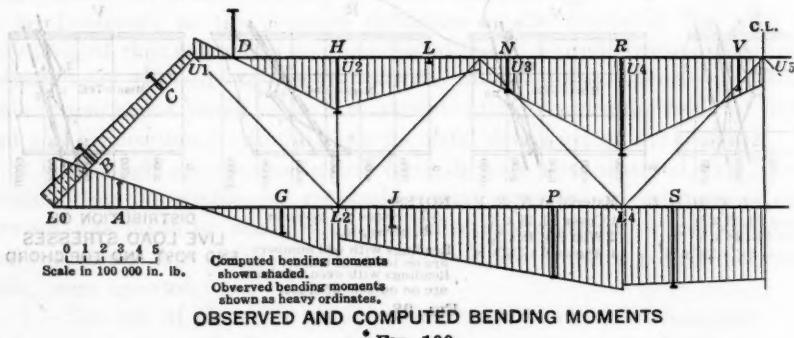


FIG. 100.

The somewhat erratic distribution of stress indicated by these measurements need not be ascribed entirely or even mainly to errors of measurement. In the somewhat rough measurements made with ordinary strain gauges reading only to 0.0001 in. considerable irregularity is indeed inevitable. It is, however, the speaker's experience that even when using instruments of precision under laboratory conditions, where every precaution is taken to preclude the possibility of serious instrumental error, the stress distribution in built-up members is, in general, far from planar across the section, and often apparently erratic, although, on the whole, checking satisfactorily with the applied loads. Even in such a simple element as an apparently straight plate in tension, this effect is very noticeable, while in built-up members kinks in the component parts—latticing, splices, tie-plates, diaphragms, and end connections—all have their effect. The increments of stress arising in this manner may often amount to from 10 to 20% of the axial stress, and, in compression members, at least, are possibly a greater source of weakness than secondary stresses of similar magnitude, since their largest values are not necessarily confined to the ends of the members.

In the truss discussed, the chords were relatively rigid as compared with the gusset-plates, and the latter had apparently little effect on the secondary stresses. The secondary stresses in an experimental truss with relatively slender members and rigid gusset-plates were measured by the speaker's col-

league. Professor H. M. Lamb, in the testing laboratory of McGill University. Sensitive mirror extensometers were used, and the measurements were made with a high degree of precision. In this case the observed and calculated primary stresses agreed very closely. The observations also showed a linear variation of secondary stress from one end of a member to the other in perfect agreement with theory. The observed values of the secondary stresses were, in general, higher than the calculated values; but an analysis taking into account the influence of the gusset-plates gave a considerably closer agreement. These two trusses were probably near the opposite extremes as regards relative rigidity of members and gusset-plates, and the data obtained from them suggest that actual secondary stresses, where the elastic limit is not exceeded, are likely to lie between the values as ordinarily calculated and those calculated by some method which takes the rigidity of the gusset-plates into account. The speaker thinks it is incorrect to conclude that, as is sometimes stated, actual secondary stresses due to rigidity of joints are necessarily less than those calculated by the usual methods.

The proper provision to make for secondary stresses, after they have been determined, is by no means an easy matter to decide. There are probably few structures that, if subjected to the full loads for which they were designed, would not show local stresses approaching or even exceeding the elastic limit of the material. In fully loaded eye-bars, for example, it is well known that such is the case. In old and overloaded structures excessive local stress must be quite common; and yet these structures may function safely for long periods. The speaker suggests that a thorough strain-gauge survey of some of these old structures would give information of great value in guiding engineering judgment as to the proper provision to make for secondary stresses generally. Tests to destruction of specially designed structures have been advocated and would be highly interesting. In such tests, however, it is difficult, if not impossible, to ascertain the effects of repeated loading, while in old structures judiciously selected, the information required would be, in a measure, at hand.

GEORGE E. BEGGS,* M. AM. SOC. C. E.—It is possible to determine the secondary stresses in the member of a truss by a laboratory study of an elastic model. Such a model should simulate the elastic action of the truss as nearly as possible. If the model is cut from sheet material, as celluloid or cardboard, the width of the model members should be proportional to the cube root of the moment of inertia of the actual cross-section of the truss members. The effect of gusset-plates may be closely represented.

If such a model is supported on a flat drawing board, with small steel balls between the model and the board, and with hinge and expansion bearings, as indicated in Fig. 101, the influence values for the shear and moment in any member, as 5-7, may be obtained by attaching a "deformeter gauge" to this member, by introducing in such member rotative and shear deformations and by measuring with a microscope the deflections of the load points of the

* Associate Prof., Civ. Eng., Princeton Univ., Princeton, N. J.

structure. A full description of this method of mechanical solution is given in a discussion of the paper by A. C. Janni, M. Am. Soc. C. E., entitled "The Design of a Multiple-Arch System and Permissible Simplifications".*

Suppose, for example, it is desired to find the bending moment at Section *AB* in the member, 5-7 (Fig. 101) caused by a load, *P*, at a panel point, 9. Introduce into the deformeter gauge plugs of unequal diameter so as to produce in the member, 5-7, at Section *AB*, the angular deformation indicated by Fig. 101 (I). With a measuring microscope set over a point, 9, and oriented in the direction of *P*, read the first deflected position of Point 9. Reserve the unequal plugs in the gauge so as to produce in the member, 5-7, the angular deformation indicated by Fig. 101 (II). Read with the microscope the new deflected position of 9. It follows from Maxwell's theorem that the bending moment in *AB* is given by:

$$M \text{ (foot-pounds)} = \frac{\Delta_P}{\Delta_G} \cdot P \text{ (m)}$$

in which Δ_P equals the component of the deflection of the load point, 9, in the assumed direction of *P* lb., *m* equals the scale of the model such that 1 in equals *m* ft., and Δ_G is the total angular deformation in radians introduced at Section *AB*.

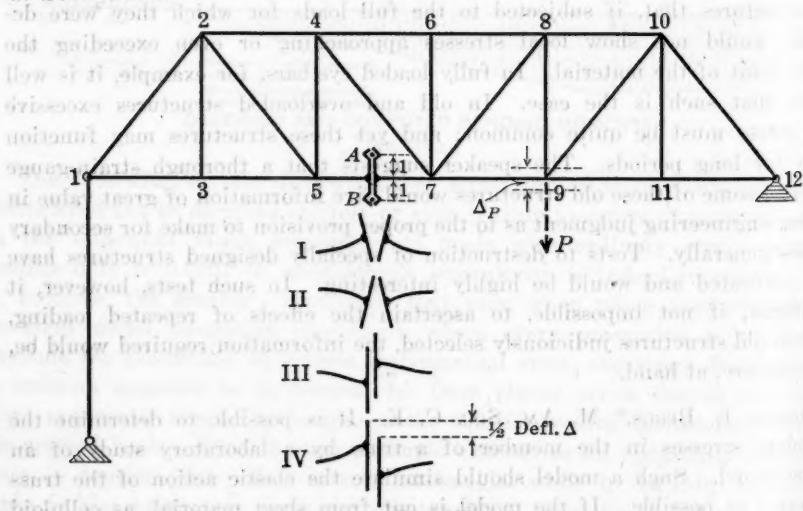


FIG. 101.

To obtain the shear at the same section, introduce into the gauge suitable plugs to produce the shearing deformation indicated by Fig. 101 (III) and (IV). Read the corresponding component deflection, Δ_P , of the load point, *P*. If Δ_G now represents the shearing deformation at Section *AB* to the same scale as that used in measuring Δ_P , it again follows by Maxwell's theorem that the shear, *S*, at Section *AB* is given by:

$$S = \frac{\Delta_P}{\Delta_G} \cdot P$$

* Proceedings, Am. Soc. C. E., January, 1925, Papers and Discussions, p. 93.

The direct, or normal, stress in the member is most easily computed by Mechanics. The bending moment at any other section of this member, 5-7, readily follows from the known moment and shear at Section *AB*. For example, at a section distance, *x*, to the right of *AB*, the bending moment is

$$M_x = M + Sx$$

It is apparent, therefore, that the resultant fiber stresses at any section may now be determined by the familiar formula:

$$S = \frac{P}{A} \pm \frac{Mc}{I}$$

= unit stress due to direct stress \pm unit stress due to bending.

D. B. STEINMAN,* M. AM. SOC. C. E.—Bridge engineers are indebted to Mr. von Abo for his excellent treatise on secondary stresses—a valuable contribution to technical literature.

The comparison of different methods applied to the same problem is instructive. The author's conclusion that Winkler's method (modification of Manderla's method) is to be preferred over the others for practical application agrees with the previously published conclusion of the speaker.†

For the solution of the series of simultaneous equations involved in the secondary stress computations, Mr. von Abo expresses a preference for Gauss' method of "normal equations." The speaker has always preferred that of "successive substitutions", which he believes to be more attractive to the practicing engineer. It is a slide-rule method, continuously self-checking, and self-correcting; it dispenses with formal rules of procedure; it permits curtailment of calculations after one or two substitutions if the last degree of precision is not required; and it reduces the tediousness of secondary stress computations. Actual comparisons show that the method of "successive substitutions" is more expeditious in practice and proves an effective check against errors; on the other hand incorrect results have been obtained by the method of "normal equations" without the computers becoming cognizant of their errors.‡

Several of the discussors have referred to the effect of the gussets at the ends of the truss members in producing a difference between the calculated and the measured secondary stresses. A logical method for including the influence of the gussets in the analysis is to abandon the conventional initial assumption of constant moment of inertia throughout each member and to substitute the assumption of varying moment of inertia. The value of *I* may properly be taken as constant over the intermediate length of each member between gussets and as increasing uniformly from these points to the theoretical ends of the member. This revised assumption affects only the numerical constants in the basic moment equation; otherwise, the computation of secondary stresses is unaltered. If this modification is used, the error due to the effect of the gusset is practically eliminated. This procedure was used in the calculations for the new railway arch bridge over the Niagara River for the Michigan Central Railroad.

* Cons. Engr., New York, N. Y.

† "Stress Measurements on the Hell Gate Arch Bridge," *Transactions, Am. Soc. C. E.*, Vol. LXXXII (1918), p. 1073.

‡ *Transactions, Am. Soc. C. E.*, Vol. LXXXII (1918), pp. 1130-1131.

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It has been stated that actual secondary stresses may sometimes exceed the calculated values; this will not be the case if the secondary stresses are calculated correctly. The assumption of a varying I near the ends of members is a simple correction that has been overlooked by past writers on secondary stresses.

The standard methods of secondary stress analysis described in the paper are, at best, long-winded and tedious. The need of the bridge engineer is for practical short-cuts that will quickly give approximate values of the secondary stresses at any selected points of a structure. Published treatments of secondary stresses appear to be confined to the longer, academic methods which yield a degree of precision not warranted by the accuracy of the underlying assumptions nor by practical requirements. The speaker has developed simple graphic methods which quickly give approximate values of the secondary stresses in any member without requiring a lengthy analysis covering the entire structure. Actual comparison of these values with the results obtained by the standard methods show an agreement within a small percentage. This is certainly sufficiently accurate for practical purposes, and the time required is a matter of minutes instead of hours. The speaker hopes to publish at an early date his simplified methods for the practical estimating of secondary stresses.

To introduce symbols and nomenclature to be used in the discussion of secondary stresses.

THOMAS C. SHEDD,* Assoc. M. Am. Soc. C. E. (by letter).†—Although this paper admittedly presents nothing new in the theory of secondary stress calculations it brings together under one heading, and in one language, most of the methods already proposed for determining such stresses. As a result it will be of great value to one interested in a critical study of the various methods.

In his Introduction the author states‡ that:

"In recent specifications the tendency is to recognize the importance of secondary stresses. Higher unit stresses are properly permitted for combinations of secondary and primary stresses. This undoubtedly leads to a better distribution of metal and to a more uniform strength throughout the structure".

It will be interesting to examine these statements somewhat further. Among the most recent specifications are those of the American Railway Engineering Association, issued in 1920 and revised under date of May, 1922. These specifications have had a remarkably wide acceptance in the short time since their publication. To the end of 1922, according to a report§ made to the Association, 79 railways with a combined mileage of 170 320 miles "have either adopted the A. R. E. A. Specifications in complete form or incorporated their provisions in their own specifications, or have signified their intentions of following one or the other of these courses as early as practicable". Of these 79 roads, 75 with a combined mileage of 169 690 are listed by the Interstate Commerce Commission with the 262 541 miles of Class I railroads. Thus,

* Associate in Structural Eng., Civ. Eng. Dept., Univ. of Illinois, Urbana, Ill.

† Received by the Secretary, December 15, 1924.

‡ *Proceedings*, Am. Soc. C. E., September, 1924, Papers and Discussions, p. 970.

§ *Bulletin*, Am. Ry. Eng. Assoc., October, 1923, p. 4.

these specifications within a period of three years after their issuance have been accepted as authoritative for the design of bridges on 65% of the first-class railway mileage in the United States. It is not unreasonable to assume that there have been further acceptances since the preparation of the report here mentioned.

In view of this widespread use of the ruling of these specifications regarding secondary stresses may fairly be taken as representing current practice in the United States. The ruling is found under "Secondary Stress",* Paragraph 47, and reads as follows:

"Designing and detailing shall be done so as to avoid secondary stresses as far as possible. In ordinary trusses without sub-paneling, no account usually need be taken of the secondary stresses in any member whose width measured in the plane of the truss is less than one-tenth of its length. Where this ratio is exceeded, or where sub-paneling is used, secondary stresses due to deflection of the truss shall be computed. The unit stresses specified in Article 38 (16 000 lb. per sq. in. basic) may be increased one-third for a combination of the secondary stresses with the other stresses, but the section shall not be less than that required when secondary stresses are not considered."

A clause identical in meaning and nearly identical in wording is included in the Final Report on Specifications for Design and Construction of Steel Railway Bridge Superstructure,† presented by the Special Committee on Specifications for Bridge Design and Construction of the Society, and also in the Final Report on Specifications for Design and Construction of Steel Highway Bridge Superstructure‡ by the same Committee. As further evidence of the recent tendency to recognize secondary stresses, it may be mentioned that the Standard Specifications for Steel Highway Bridges adopted by the American Association of State Highway Officials and published by the U. S. Department of Agriculture,§ contains a clause similar to that of the reports of the Special Committee of the Society except that the allowable increase in unit stress when secondary stresses are included with other stresses is 30% instead of 33½ per cent.

In contrast with the specifications mentioned—which require that secondary stresses be computed in certain cases—are the 1917 Specifications of the New York Central Lines which, without qualification, definitely require that secondary stresses be computed; Paragraph 48 reads:

"The secondary stresses in truss members due to rigidity of joints and the deflection of the truss shall be computed. The unit stresses in Paragraph 41 (18 000 lb. per sq. in. basic) may be increased one-third for a combination of the axial stresses and the above mentioned secondary stresses. Stresses due to eccentricity of transverse bending shall be computed. * * * For a combination of axial stresses and stresses due to eccentricity and transverse bending the unit stresses in Paragraph 41 shall not be exceeded."

Somewhat less definite than the others, but nevertheless showing the present tendency, are the 1916 Specifications of the Pennsylvania Railroad which,

* "General Specifications for Steel Railway Bridges 1920", Am. Ry. Eng. Assoc., Second Edition.

† *Transactions, Am. Soc. C. E.*, Vol. LXXXVI (1923), p. 47.

‡ *Transactions, Am. Soc. C. E.*, Vol. LXXXVII (1924), p. 1273.

§ *Bulletin No. 1259*, U. S. Dept. of Agriculture.

in Paragraph 24, require that: "All bending and other secondary stresses in addition to direct stress are to be provided for."

These clauses, cited from various specifications, not only clearly support the author's statement regarding the tendency of recent specifications to recognize the importance of secondary stresses, but seem to indicate that the majority of railroad bridges in the United States are now designed under specifications definitely requiring more or less consideration of such stresses.

The other statements by the author, namely, that "higher unit stresses are properly permitted for combinations of secondary and primary stresses", and that "this undoubtedly leads to a better distribution of metal and to a more uniform strength throughout the structure", should be considered together.

It does not seem that current specifications offer much support to this thesis. It is true that all the specifications cited—with one exception—permit an increase in the allowable unit stress of one-third (30% in one case), but—with the same exception—they include a qualifying clause which in substance requires that "the section shall not be less than that required when secondary stresses are not considered."* The result is that unless the secondary stress exceeds 33½%, there is no change whatever in the distribution of the metal and the strength of the structure is no more uniform than if secondary stresses had not been considered.

It is this feature of current specifications which seems objectionable to the writer. In the case where secondary stresses have been computed, the tendency will be to assume that the structure has a better distribution of metal and a more uniform strength than in the opposite case—an assumption which is not supported by the facts. It is true, of course, that some metal may have been added at the points of high secondary stress, but the fact remains that some members having little or no secondary stress will be working at the basic unit stress while others will have a unit stress varying from the basic value to a value one-third higher. The result is a structure which does not have uniform strength; some members are wastefully proportioned, or else other members are over-stressed, depending on whether or not the basic stress be considered too high. This is not necessarily a dangerous condition (if it is, most of the bridges now in operation are in a dangerous condition). The danger is that engineers will convince themselves by the multiplicity of their calculations and the complexity of their analyses that they have greatly improved their structures. They may know more about the actual stress conditions, which is very desirable, but it is certain that by complying with specifications as at present written they will have done little toward securing greater uniformity of strength.

In the 1916 Specifications of the Pennsylvania Railroad, the clause dealing with secondary stresses (Paragraph 24 quoted previously) is not definite, but the writer understands that where secondary stresses are included with primary stresses the allowable intensity of stress is not increased. This is the correct method of design. If secondary stresses are calculated and included with primary stresses in an effort to secure a better distribution of metal the same unit

* "General Specifications for Steel Railway Bridges, 1920," Am. Ry. Eng. Assoc., Second Edition.

stress must be used in all members whatever the amount of secondary stress. Whether that unit stress should be the one now in common use or a higher one is entirely another question. The writer believes that when the problem of secondary stress has been thoroughly analyzed higher unit stresses may properly be permitted.

Emphasis should be placed on the matter of thorough analysis. If secondary stresses are to be added to primary stresses both must be simultaneous; this involves the question of whether the maximum primary stress combined with the simultaneous secondary stress will be greater than the sum of some other greater secondary stress combined with its simultaneous primary stress. The problem does not have an obvious answer and its solution requires extensive calculations.

Assuming, however, that the necessary computations have been made there are still many problems. All the methods thus far proposed for the determination of secondary stresses, assume, for a given member, a constant moment of inertia from intersection to intersection. This is obviously not the case; for heavy trusses with large, thick, or multiple gussets and outside splice-plates at the connections, the error becomes considerable. Correcting for this condition by the method suggested in an interesting article by O. H. Ammann,* M. Am. Soc. C. E., there still exists the uncertainty of the distribution of stress (secondary and primary) in the joints—about which practically nothing is known at present. Many engineers are of the opinion that this question is one which cannot be solved.

It is not apparent that the inclusion of secondary effects increases the uncertainty already existing in a discussion of joints with respect to primary effects. If the methods of joint analysis (crude though they are) are extended to include secondary effects, it would seem justifiable to assume that at least as much is known as though secondary effects had been disregarded. If that is correct then this uncertainty, serious though it is, should not be considered an impassable barrier to improvement in design by a consideration of secondary stresses.

At present little is known as to how the consideration of secondary stresses will affect the economics of design and construction. Should such stresses be reduced by placing restrictions on the ratio of width to length of members, and if so, should the length be defined as the distance between intersection points or the clear distance between joint plates? Is it proper to ignore the secondary stresses if the limiting ratio is met, and if not should they be eliminated, either partly or entirely, by adjustments of lengths of members and angles between them, or should additional metal be provided to keep the maximum stresses within the prescribed basic stress? Which method leads to the structure having the greatest strength and wearing qualities for the quantity of metal used, and which to the greatest ultimate economy?

The writer is a firm believer in thorough-going studies of secondary stresses but holds that investigation and discussion of the problems just mentioned is the immediate need rather than the further elaboration of the mathematics of analysis.

* *Engineering News-Record*, October 23, 1924, p. 666.

systems, which is to furnish full reliability through the fair use of power and to develop a steady movement of power over all lines, so that there will be no need for any power plant to serve its own load.

THE INTERCONNECTED POWER SYSTEMS OF THE SOUTHEAST

Discussion*

By MESSRS. E. A. YATES AND EDGAR A. VAN DEUSEN

E. A. YATES,† Assoc. M. Am. Soc. C. E.—The seven major power companies of the Southeast are the Carolina Power and Light Company in the eastern portions of North Carolina and South Carolina; the Southern Power Company in the middle portions of North Carolina and South Carolina; the Georgia Railway and Power Company in Central and North Georgia; the Central Georgia Power Company at Macon, Ga.; the Columbus Power Company at Columbus, Ga.; the Alabama Power Company in Alabama; and the Tennessee Power Company in Tennessee. All these companies have interconnection and realize its value. Largely by reason of the efforts of the Georgia Railway and Power Company, the present interconnecting lines have been built. This Company being geographically at the center, or so-called "hub", it has been logical that the interconnecting lines should develop radially from it. Considering that the interchange of power between these companies was approximately 85 000 000 kw-hr. in 1922, and nearly 240 000 000 kw-hr. in 1923, and that some of the lines were operated in 1923 largely in excess of their rated capacity, it would seem that more interconnections are necessary. They are needed along the outside, that is, from outlying companies. The Alabama Power Company and the Tennessee Power Company are now contemplating a high-tension connection between Alabama and Tennessee, and a new connection will be made in the near future through the Tennessee Valley, connecting the Tennessee power lines at Knoxville, Tenn., and the lines of the Southern Power Company in North Carolina. This connection will provide a second trunk line from Alabama to North Carolina.

The advantages of interconnection are obvious to any student of power distribution. The increase in reliability of service, the guard against breakdown, the absorption of excess capacity from the plant by all the companies during the period of loading, and the greater utilization of water, are all arguments favoring interconnection and interchange of power.

Co-ordination and co-operation between the large companies emphasizes the principle that power facilities should be created with a view to the aggregate and not the individual demands, reduction of costs, and reliability of service. This does not mean encroachment of one power company on the territory of

* Discussion on the paper by Charles G. Adsit, M. Am. Soc. C. E., continued from December, 1924, *Proceedings*.

† Vice-Pres. and Gen. Mgr., Alabama Power Co., Birmingham, Ala.

a neighbor, nor that one company supplies another with average load energy, but it does mean closer co-operation and use of excess capacity. The joint-load principle is recognized as desirable, and, in the future, a closer co-operation will be carried even to the investment of capital of connecting companies to provide for power-producing facilities. There are a limited number of streams and rivers susceptible to development, and a limited quantity of power capable of development; nothing can justify a lack of co-ordinate development and operation of these sites so that, as nearly as possible, they may provide 100% use. The steam plants, the storage water plants, and the run-of-river plants, of all these companies should be operated so as to utilize the greatest quantity of water and burn the least coal.

These seven companies generated approximately 3 000 000 000 kw-hr. of energy during 1923 (an increase of 20% over 1922), and each company is now engaged in the construction of one or more generating plants, both steam and hydro-electric, to keep abreast of local market demands. It is reasonable to believe that this rapidly increasing demand for energy in the South is to continue. Climate, labor, and transportation have all been large factors in the development of the South; reliable and reasonably priced power has been one of the greatest factors.

Interwoven with the network of transmission lines and generating plants of these companies is the power situation at Muscle Shoals.¹⁷ Located, as it is, in the northwestern part of Alabama, on the Tennessee River, near the State line, this great source of water power, an unusually large proportion being secondary, is exceptionally well situated for use in a super-power distribution system in the South, extending to the western part of Tennessee and to Mississippi. Only by the operation of the Muscle Shoals plant in co-ordination with the power-producing facilities, both water and coal, of these States can the greatest utilization of these developments be realized. The Muscle Shoals development is a run-of-river plant and, although it will eventually have an installation of approximately 800 000 h.p., the low flow of the Tennessee River reduces the absolute primary power to about 140 000 h.p. In order that this power development may be utilized to the utmost, it is essential that it be supplemented by steam and by the storage water plants of the companies of the Southeast.

The Muscle Shoals section of the Tennessee River covers a fall of approximately 135 ft. The dual purpose of navigation and power will be served by the construction of two dams; the Wilson Dam, known as Dam No. 2, with a head of 93 ft., is now nearing completion. Construction of Dam No. 3, upstream, with a head of 40 ft., will be started on completion of the present work.

In 1914, the Alabama Power Company acquired all the lands and rights at these dam sites and expended approximately \$500 000 in land, borings, surveys, and engineering studies looking toward the development of these two sites for the joint purpose of navigation and power.

On two occasions prior to the World War, agreement was reached by the Power Company and the Board of Engineers of the United States Army,

whereby in part the expense of the development would be borne by the United States in the interest of navigation, and in part by the Power Company in the interest of power.

At the beginning of the War, it was decided to establish the great nitrate plants at Muscle Shoals, building Dam No. 2 to supply the power. (Here, also, it is proposed that fertilizer production shall be carried on by the manufacture of nitrogen and other ingredients of fertilizer in a concentrated form.) It is not generally known that the Alabama Power Company gave the Government all its rights to Dam No. 2 at Muscle Shoals, representing in the aggregate approximately \$500 000. Further than that, it built an addition to its steam reserve plant at Warrior, 90 miles south, and installed a 30 000-kw. unit in order that the Government might have power at an early date for the construction and operation of the nitrate plants. This extension utilized the intake and discharge culverts, foundation, coal mines, tracks, and lines of Alabama Power Company. The Government recently sold this extension to the Power Company for \$3 500 000, which was just and proper, and returned to the Government a large part of its expenditures on this project.

Thus, at the end of the War there was at Muscle Shoals Nitrate Plant No. 1 and Nitrate Plant No. 2, which cost the Government in excess of \$80 000 000, together with a 60 000-kw. steam plant costing approximately \$12 000 000, and Wilson Dam, partly finished, on which the expenditure of approximately \$17 000 000 had been made.

In 1921, in response to a request from the Government, the Alabama Power Company made a further proposal for co-operation and development of Muscle Shoals, and again in 1922, still another proposal to complete this dam at its own expense, under the provision of the Federal Water Power Act, and to provide free 100 000 h.p. for use in the manufacture of fertilizer.

The industrial growth in the South during the past ten years has been largely in cotton mills, steel plants, coal mines, iron mines, and various factories, all of which use power, and in the development of which reasonably priced, dependable power has been a large factor. In 1923 these industries paid on an average approximately 1 cent per kw-hr. for their energy.

EDGAR A. VAN DEUSEN,* ASSOC. M. AM. SOC. C. E. (by letter).†—It is inspiring to see a map of the Southeastern States showing a great interconnecting and interstate power system that supplies with certainty and economy the diversified needs of a large and scattered population. The really significant fact, however, is that this achievement is the result of private enterprise—a monument to the American doctrine of co-operative individualism as opposed to the socialistic doctrines of Europe.

It is very improbable that governmental (political) ownership could have developed the "Interconnected Power Systems of the Southeast." It is conceivable, of course, that one State, through the efforts of a man of vision and forceful personality—a Sir Adam Beck—might develop its power systems into

* Asst. Hydr. and Structural Engr., Central Hudson Gas & Elec. Co., Poughkeepsie, N. Y.

† Received by the Secretary, November 8, 1924.

an effective combination; but for five adjacent States to do so contemporaneously, and, in addition, to agree to mutual interconnection and energy interchange, would require Utopian conditions. Consider as examples the present Colorado River and the St. Lawrence River controversies, in which, despite the earnest efforts of qualified and conscientious engineers, and other patriotic citizens, politics seem to be the dominant factor. Analysis shows that even the famed Ontario Hydro-Electric System, splendidly conceived and executed as it is, the praises of which are forever being sung by proponents of Governmental ownership, is a relatively expensive experiment in which political expediency looms large.*

The interconnection of power systems, as distinct from the super-power idea, is making great strides in America. New England, New York, Pennsylvania, the Middle West, the Northwest, and the Pacific Coast, as well as the South, can point to numerous examples of this, both interstate and intra-state. Maine, by reason of its prohibition of power export, is the only exception. Super-power systems will doubtless evolve from these projects in the course of time.

The author has drawn attention to the comprehensive scheme of power development for the Tallulah River, in which 90% of the annual run-off will be available for power generation. It is gratifying to realize that this, like interconnection, is also a trend of the times. The Catawba River, the Deerfield River, and the Au-Sable River (Michigan), are three other examples, in which a high percentage of the total run-off is transformed into power. There are doubtless other instances, to say nothing of the many projects which have been highly developed on paper, and are merely awaiting improved economic conditions before they take concrete form.

Modern business is striking a new note, "Service"; especially is this true of the public utilities of the country. The old ideas, "the public be damned", "business is business", etc., are going the way of the horse car and other anachronisms; but in spite of this and of the additional fact of "Government regulation" a safeguard for the people which practically precludes the possibility of exploitation there are still those who, honestly or otherwise, urge Government ownership and operation of some or all public utilities. Engineers owe it to themselves and to their country to examine the evidence, to draw the logical conclusions, and to educate their misinformed fellow citizens.

* See National Electric Light Assoc. Report by Mr. W. S. Murray, and the paper entitled "Truth About Electric Rates in Ontario", by Mr. W. M. Carpenter in *Electrical World*, October 25, 1924, p. 887.

WATERWAY AND RAILWAY EQUIVALENTS

Discussion*

BY MESSRS. C. H. MARKHAM, EDWARD BURR, WILLIAM G. ATWOOD,
J. R. SLATTERY, C. I. GRIMM, H. F. DUNHAM, AND WILLIAM H. BURR

C. H. MARKHAM,† Esq.—It is doubtful whether there is any important public question about which so little reliable information is given out and which is so little understood by the public generally as the question of the present use and prospective development of inland waterways. When efforts are being made to obtain Congressional appropriations for inland waterway improvements, it is usually not supporting information that is wanted by their advocates, but appropriations. Of course, before these projects are acted on by Congress, the reports of the United States Army Engineers are received, but these reports are usually not given such consideration as will interfere with obtaining the desired appropriations.

That is a strong statement, but it can be illustrated by the case of the proposed Illinois State Waterway Improvement between the Chicago Drainage Canal and the Illinois River, which is part of the plan to provide a navigable channel between Chicago and a connection with the Mississippi River at Grafton, Ill., and thereby make barge transportation possible between Chicago and New Orleans, La., a distance by water of 1,610 miles. As far as the real promoters of this project are concerned, the relation between the saving in the total cost of transportation that can be expected and the cost to the public of the proposed waterway has not been given the slightest consideration.

There is no valid objection to the development and use of a waterway where the tonnage that can be expected to move over it on its completion is sufficient to justify the expenditure of public funds raised by taxation and, therefore, paid by all the people. That sort of improvement is in the same category with the improvement of ports and harbors by the Federal Government and the contributions which the Federal and State Governments make to the construction and maintenance of public highways. However, it would hardly seem possible that those responsible for the making of Federal and State expenditures for highway improvements would contribute large sums of money for the construction of a highway located for miles through a section of the country where there would be little or no travel. Such contributions are made only under conditions where there is a reasonable prospect that intensive use will be made of the highway when it is completed. The same study should be made of proposed waterway improvements and should govern the appropriation of public funds for such improvements.

* Discussion on the paper by William M. Black, M. Am. Soc. C. E., continued from December, 1924, *Proceedings*.

† Pres., Illinois Central R. R. Co., Chicago, Ill.

The advocates of the development of inland waterways almost invariably seek to reinforce their arguments with the statement that the railroads have broken down and shown themselves unable to handle the traffic offered from time to time. If it is pointed out that during the last two years (1923-24) the railroads have been furnishing all the increased transportation required, they reply that the future rapid growth of the business of the country will find the railroads unable to meet future requirements, and hence it is necessary to supplement the nation's domestic transportation machinery with inland waterways. Still another argument is that the development of inland waterways will relieve the railroads of a large part of their freight traffic that is carried at low rates, such as coal, grain, lumber, and the like, which, they assert, is unprofitable to the railroads.

The truth about the latter argument is that almost any American railroad would starve to death if its heavy freight business were taken away from it, because that is the freight that pays best. A railroad would rather handle coal at one-fourth the rate per ton per mile that it receives for handling merchandise. Coal moves in carload shipments, and cars are loaded to the maximum, thereby reducing the proportion of dead weight that has to be carried; it is handled in heavy train loads, making for economy in train operation; and there are comparatively few claims to pay. Altogether, even at comparatively low rates, it is the most profitable business the railroads handle. That ought to dispose of the argument that the development of waterways is desirable from the standpoint of relieving the railroads of that part of their business on which comparatively low rates are charged.

Concerning the argument that waterway development is needed to help meet the transportation requirements of the future, there is this to be said: It is beyond physical possibility that inland waterways can ever be developed to the extent of making any considerable contribution to the total volume of freight traffic that must pass between points in the interior of the country. The total volume of both foreign and domestic commerce handled into and out of all the ports of the United States and its dependent territories—including export, import, and coastwise business, but eliminating the Great Lakes and not counting coastwise traffic twice, as is done in the keeping of records—was about 96 000 000 tons in 1923. As against this, the railroads handled 1277 000 000 tons. The Illinois Central System, comparatively a small railroad, alone handled 65 000 000 tons, or about two-thirds as many tons as the total number of tons of import, export, and coastwise freight handled into and out of all the ports of the country, except the Great Lakes. That ought to dispose of the argument that inland waterways—a relatively small factor in the nation's total water-borne commerce, which is principally foreign commerce—can ever be of material assistance in helping the railroads to meet the increased transportation requirements of the future. The main reliance for domestic transportation must still be placed on the railroads, as it has been in the past.

Although it is true that the railroads for some time have been handling about all the traffic possible with their present facilities, there is no conceivable limit on the amount that can be handled if they are enabled through

adequate earnings to maintain their credit and increase their facilities. Their business has increased 800% in the last forty years, and they have met that increase creditably. That is assurance that they can do as well in the future if given the support which the public interest demands.

As regards the savings that can be effected by the use of waterways as compared with the costs of providing and maintaining them (which is the real test of waterway economy), the speaker submits the following:

The total capital cost of the New York State Barge Canal, up to June 30, 1924, including the Erie Canal and the various branches, was \$168 053 962.31. Capitalized at 4%, that makes an annual interest charge of \$6 722 158.49. The expense of operating and maintaining them in the fiscal year ending June 30, 1924, was \$4 099 975.67. This, added to the interest charge on capital investment, makes an annual charge against the traffic carried by the New York State Barge Canals of \$10 822 134.16. The entire New York State Barge Canal System in the calendar year 1923 carried 2 572 635 tons of freight, so that the annual charge for interest on investment and the cost of maintenance and operation averaged \$4.21 per ton. Now, a charge is high or low by comparison. The average revenue received by the railroads in 1923 for each ton carried was \$1.97, and this was in full payment for all the service, not merely the cost of providing the roadbed over which their trains could be operated. The charge against the traffic of the New York State Barge Canals of \$4.21 per ton covers only the cost of providing and maintaining the canals and does not include the boat lines' charges for handling the freight.

The experience on the Monongahela River is often referred to. In 1923, the Monongahela River carried 23 562 925 tons of freight, of which 18 709 084 tons was coal. Its traffic in 1923 was larger than ever before, an increase of nearly two-thirds over 1922. All that business is short haul. It is carried in vessels of the owners of either the coal mines or the steel companies to which the coal is brought and from which small quantities of steel products are carried away. The United States District Engineer in charge of the Monongahela River improvement states that there are no common carriers operated on that river. To all intents and purposes, the Monongahela River improvement is a plant facility for the large corporations which use it. The cost of operating and maintaining the Monongahela River improvement project in the fiscal year ending June 30, 1924, was \$819 273, or about 5.7 cents per ton on the 1922 traffic of 14 407 129 tons, or 3.5 cents per ton on the 1923 traffic of 23 562 925 tons. This is simply the cost of operating and maintaining the improvement, not counting an interest charge on the expenditure of nearly \$10 000 000 for canalizing the river, providing the regulating works, etc., nor the cost of operating boats.

It has been suggested that one reason why a greater amount of traffic has not been developed on the Ohio River is that the work has not been completed as quickly as was contemplated when the first appropriations were made.

The present project for the improvement of the Ohio River was adopted in 1910. At that time it was estimated that it would cost \$63 731 488 to complete the series of fifty-two locks from the head of the river at Pittsburgh.

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Pa., to its junction with the Mississippi River at Cairo, Ill., a distance of 968.5 miles. According to the latest report, thirty-seven of those locks have been completed, the United States Army Engineers are working on eight others, and seven are untouched. The Federal Government had spent, to June 30, 1924, on all projects, a total of \$76 788 387. It is estimated that it will cost about \$43 000 000 to complete the work. If that is true, the entire project will have cost, in round figures, \$120 000 000, or virtually twice the original estimate.

There is not enough water in the Ohio River now to navigate those parts that have not been provided with locks, so that for a considerable length of time the river will be out of use, until the volume of water increases. The Ohio River handled in 1923 only 8 280 520 tons of freight. How much more it will handle after the project has been completed is a matter of conjecture.

Advocates of the development of inland waterways often refer to the use that the European countries are making of their waterways, on one hand, and the use that is being made of the Great Lakes in the United States, on the other. Whenever the navigation of rivers in European countries is referred to, it is the German Rhine that is meant, as the Rhine is the only river in Europe that is being used extensively, with the exception of the Elbe in Germany. In this connection, it is highly important to note that Germany was a thickly populated country with good sized centers of population long before railroads were known. All the towns and cities and commercial interests that had been developed up to the time of the railroads were located on the waterways. In addition, the Rhine flows through the important Westphalian coal fields, and the location of those coal fields determines the location of industries along the river in the Ruhr District, concerning which so much has been heard recently. The iron ore for use in the steel plants of the Ruhr comes by sea to Rotterdam, is delivered to the German Rhine at Emmerich, and thence moves up the Rhine to the German industries.

Starting with the double advantage of the location of not a few considerably sized towns and cities on the Rhine and the natural location of the river with reference to the large coal fields and dependent industries, when the time came for an intensive development of the railway systems, what was done? The railroads of Germany, like the railroads of America, never began to assume development proportions worthy of the name until after the Franco-German War. That experience, perhaps, with inherited traditions going back many hundreds of years, pointed to the direction in which railway construction should take place, and that direction, according to the German mind, was toward the Belgian and French frontiers. As transportation agencies the use of railroads was subordinated to the use of waterways and to the fact that when needed they might be available for military purposes. To that end not only were the railroads constructed toward the frontiers, but the Government owning the railroads made the rates high enough to encourage the use of the waterways and discourage the use of the railroads. How can a comparison that is worth anything be made between the use of a waterway developed under those conditions and the theoretical use of a waterway under entirely different conditions in the United States?

Concerning the reference that is often made to the low cost of freight transportation per ton-mile on the Great Lakes, it is hardly fair to compare the transportation of iron ore, coal, and other bulky commodities in 12 000-ton vessels, using the most modern labor-saving devices for loading and unloading the tonnage in huge volume, with the transportation of hats and caps and boots and shoes and all the various other articles of general commerce by the railroads, across rivers and plains and over mountain tops. Yet that is the kind of argument that often is broadcast by advocates of inland waterway development.

Take another inland waterway, the Lower Mississippi River, which is virtually paralleled by the lines of the Illinois Central System. During the World War, the Director-General of Railroads recommended an expenditure of about \$12 000 000 to provide transportation on the Lower Mississippi River to take care of the business that the railroads at that particular time were unable to handle. The appropriation was finally made, and the Federal Barge Line has thus been in use since 1919. It has been properly regarded as an experiment to determine the possibilities of barge operation on the Mississippi River.

The Illinois Central System from the beginning has co-operated with the management of the Barge Line in every conceivable manner—establishing interchange facilities at meeting points and making agreements concerning the division of through rates which have been entirely satisfactory to the Barge Line management.

An old story will perhaps illustrate some of the reasons for this policy of the Illinois Central System. A Western Congressman, in the early days of Populism, talking with a friend in Washington, said that he had just received news about the alarming growth of Populism in his State, and that he must go back and look into the matter. His friend said, "I suppose if you go back and find they are that strong, you are going to fight them." "No," he said, "if I find them that strong, I am going to join them."

From the beginning the speaker has had no faith in the success of the Mississippi experiment except on a basis of continued subsidization by the Government or the creation of conditions which in the end result in the total cost of transportation being greater than if it is carried by rail. Not having counted on the success of the experiment, he did not want it to be said, when it did fail, that the Illinois Central System had made any contribution toward that failure. On the other hand, if by any chance it did succeed, then the Illinois Central System would be in a position where, if opportunity offered, it might share in some of the credit.

As a member of the Waterways Committee of the United States Chamber of Commerce which made a report several months ago on the question of the development of waterways and their co-ordination with the railroads for transportation service, the speaker joined in its recommendation that, to determine more fully the possibilities of inland waterway transportation, the Secretary of War should be given the necessary authority and funds to operate the barge lines on the Mississippi and Warrior Rivers in accordance with good commercial practice. Shortly afterward Congress appropriated several million

dollars for use under the direction of the Secretary of War in handling the business of the Mississippi-Warrior Service along commercial lines. It was well argued by Brig.-Gen. T. Q. Ashburn, U. S. A., who is in charge of that work under the Secretary of War, that one of the reasons they were unable to handle the business successfully was that if in one year they made a profit, it went into the general fund, and they were not able to use it the next year, if there was a loss. Another argument was that under existing conditions they were not in a position to act freely because of the necessity of turning back money to the United States or going to Congress for various other needs.

From the beginning of barge line operation to June 30, 1924, the Mississippi River line took in \$11 532 250 and paid out \$14 541 496, or \$3 009 246 more than was received. In addition, depreciation charges amounted to \$1 791 160, making a net deficit, including depreciation, of \$4 800 406. Something ought to be allowed for pioneer waterway development, as General Black has said, but the fact is that in the fifth year of operation of the Barge Line—after the completion of its pioneer work—there was a deficit of \$254 000 before depreciation and of \$679 000 after depreciation; and nothing is included therein to represent the cost of providing and maintaining a navigable channel in the Mississippi River, which has been no inconsiderable sum.

A present, the Barge Line is having great difficulty in getting its barges over the sand-bars on account of low water. There is no navigation between St. Louis, Mo., and Cairo, and the movement of tonnage between Cairo and New Orleans has been very light and very slow on account of the lack of water in the river. It does not do to say, however, after using a vast amount of the nation's money, that the Barge Line's inability to earn a return is because the river is too high, or too low, or has ice in it. Those are hazards that the business ought to be expected to encounter; it is one of the things that ought to be taken into consideration when the Federal Government undertakes to spend public money in developing the waterways.

In this same connection reference has been made to the fact that in the early days of the railroads they were built largely by Government subsidies. As for the money that was advanced by the Government to the transcontinental lines, every dollar of it has been repaid with interest. It is true that the Government gave some of the railroads land in addition to money, and, of course, the land has been kept. The Illinois Central was one of the land grant roads; it was begun in 1851. Its promoters agreed to build it if the State would secure from the Federal Government a grant of land for a right of way and a certain number of alternate sections on either side. The Federal Government ceded to the State of Illinois more than 2 500 000 acres of land to secure the construction of a railroad in Illinois from the Great Lakes to the Ohio River at Cairo, and also ceded to the States of Tennessee, Mississippi, and Alabama certain grants of public lands to secure the construction of a railroad from the Ohio River to the Gulf of Mexico, at Mobile, Ala.

The Illinois Central accepted the grant from the State and took the 2 500 000 acres of land. The Government required, however, that the railroad should forever carry its property and its passengers at certain reductions in rates. The first requirement was that the railroad should provide the

roadway and the Federal Government should be allowed to operate its own cars and engines over it. Somebody had a theory that that could be done. Afterward that part of the agreement was changed, and it was put on the basis of reduced rates. Since that arrangement has been in effect, the Illinois Central has given the Government about \$7 000 000 in rate reductions. At the time there was no demand for land in Illinois because there was no transportation. As soon as the Illinois Central accepted these 2 500 000 acres, lying in alternate sections, the Government advanced the price of the remaining sections to \$2.50 per acre, and, when the land began to sell, the price was advanced by degrees above that, so that although the Government may have given the land to the Illinois Central, it was a good thing for the Government, which repaid itself by the stroke of a pen, not to speak of the \$7 000 000 returned in reduced rates.

As to the State, the Illinois Central accepted an agreement by which it was to pay 7% of the gross receipts of its charter lines into the State Treasury. The result is that the Illinois Central System has already paid the State \$60 000 000. Last year (1923) alone it paid more than \$3 500 000 in addition to some other taxes.

It cannot be said that the Government through its land grants and other subsidies did so much for the railroads as might be thought even if merely the fact of having made these early contributions is taken into account, without considering that every dollar of that money has been repaid, in some cases many times over.

Concerning Colonel Slattery's reference to rates between water route points and non-water route points, it should be remembered that it was not until the railroads were built that there was any considerable transportation except by water. The railroads were built under the same conditions that highways are being built to-day. A great deal of money is now being spent in Illinois for the improvement of public roads. They are being built alongside the railroads, because that is where the towns are and that is where the business is. When they come to the towns that are already served by the railroads, no criticism is made; it is a natural development—one of the things that is occurring in this age—and one would be foolish to protest against it.

That is exactly what happened in the construction of many railroads. Take, for example, the construction of the railroad from Memphis, Tenn., on the Mississippi River, down through the delta of the Yazoo. When this railroad was started the only navigation possible was at the high places; the river, as it rose, inundated the whole country. The railroad, therefore, was built to those points where there was some business, and the only way it could live was to take the business there. When business slackened boats could move to other fields, but the railroad had to get enough business to live where it had laid down its rails; and to get the business the railroad had to make rates as low as the boat rates. That was in the beginning. When it came to making rates between points in the interior, the railroads naturally made the rates on the basis of what the traffic would bear.

A wise traffic man knows that it is his business to encourage the movement of traffic along artificial lines. In the present rates through the Panama Canal there is seen a correction of the difficulty Colonel Slattery has referred to, because under the present law a railroad having once reduced its rates to meet water competition cannot raise them again without the consent of the Interstate Commerce Commission. It is not permitted to raise them because the use of the water rate has been discontinued.

If the railroads were to raise their rates to the point where the business would be turned over to the highways, there would not be any competition; the railroads would go out of business.

Further, there is no such thing as real competition between a waterway and a railroad. There is no competition between the railroads and the boat lines on the Great Lakes for the ore business. Every pound goes by water, and it cannot move by rail unless there is some particular object that cannot be got into the hold of a ship. Whenever they are left without interference, either one or the other will eventually take the business. There are never two waterways side by side and competing as two railroads would or two highways.

In summary: It is not humanly possible at any figure of cost within the reach of one's imagination to develop inland waterways within the next twenty, thirty, forty, or fifty years to an extent that will make the slightest impression on the total amount of tonnage that is now being handled or that the railroads will be required to handle in the future.

There is no limit to the amount of tonnage that the railroads of the United States can put themselves in position to handle. It simply means more tracks, more cars, more engines, larger terminals. That can be done. Waterways cannot be built across mountains; they cannot be put where there is no water. Railroads can be built anywhere, and they can go on and on, and on, and furnish all the transportation that the country needs, when it needs it. All that is necessary is to treat the railroads in the matter of regulation so that when the end of a year comes there will always be enough money left, after paying operating expenses and fixed charges, to encourage continuous investment in their securities.

EDWARD BURR,* M. AM. SOC. C. E.—This paper is of value in drawing the attention of the professional public to the subject of waterways, which is always present, but usually slumbering; it notes those technical requirements that are essential to the economic planning and operation of waterways or any other transportation system, and refers in detail to the necessity for the consideration of the economics of water transportation. Those economics must be taken into account in a broad way as well as in detail in determining the advisability of undertaking any waterways improvement or extension.

The controlling element in the economic consideration of these matters is the public ownership of these highways—of water transportation routes. There is no question as to the desirability of public ownership of some publicly used facilities, nor of retaining in private ownership other public utilities.

* Col., U. S. A. (Retired), New York, N. Y.

The line between the two classes is indeterminate and shifting; but the ownership of certain transportation routes on water and on land has always been vested in the public, and the wisdom of this broad policy cannot be questioned at this time.

The earliest land transportation routes were mere trails, free to all. Whatever cost or expense of labor was involved in opening and maintaining them was borne by the public. In addition to the public highways, there have been some privately owned land highways—toll roads. They were not striking financial successes; most of them have long since been absorbed by the public. The use of public-owned highways has been free to the public, and the charges are a general assessment on the public, more or less broadly spread, depending on the scope of the benefits which they render.

There is a wide analogy between highways on the land and those on the water. In the same early periods, the water routes of the earliest settlements along the coast were of even more importance than those on land, especially for the transportation of cargo. Similarly, in the early period, the improvement by private capital of some routes and the construction of others where none existed, were not only permitted but encouraged by the public. These privately owned waterways have followed much the same course toward public ownership as did the toll roads on the land, until, at present, there are few that are thus owned and operated. The reasons in the case of water routes are much the same as in the case of land routes.

The full and free use of natural waters for navigation and other purposes has long been recognized and carefully protected as the country developed. These water routes were improved and extended by public authority, and their use has continued free to the public. This policy has come down through 100 years of Federal control and, no doubt, will continue into the future. It has had much to do with the economics of the development of water routes at the public expense.

As routes were improved or extended, such studies as were practicable as to the economic benefits to result from the expenditures of public funds have been made. Those who have had experience in making such studies are fully aware of the difficulties of arriving at a satisfactory solution—one of such reliability as fairly to forecast the future, not only as to the commerce to be developed but as to the economic benefits, special and general, to accrue to the public, the owner of the routes. That this difficulty was not peculiar to the public officers who made such analytical studies, is clear from the records of those land highways and water highways which in the past have been improved at the expense of private capital. It is evidenced by the disappearance of nearly all those routes, and by the small financial return on those which still continue in existence and operation. The explanation rests on the fact that, to-day, and in the recent past, few waterways have made an adequate direct financial return for the private capital or public funds expended on them and that the indirect benefits, especially from public, free waterways, are impossible of evaluation.

The question arises as to why these improvements should be undertaken, when no direct benefit to the owner (the public) can be shown; and when in

many cases little indirect benefit to those who might need them is in evidence through their general or systematic use.

The same question may be asked in regard to public highways on land. In how many cases of land highways, of public roads, can an economic analysis be made which will justify the construction through the showing of any adequate return direct to the owner of the roads, the public, or to the public treasury, or even any adequate indirect return?

What is it that leads the public to insist on having these facilities, at the public expense, when no analysis can prove any adequate financial return, direct or indirect? The answer is found partly in the public desire to control certain necessary public facilities rather than to allow them to pass under the control of private capital. That, however, is not all. Every one through familiarity with the results flowing from the extension and betterment of public land transportation routes, recognizes the material indirect benefits to the public and to the public funds following all worthy improvements in transportation facilities, although such benefits may not be susceptible of reliable measurement by the financial yard-stick. Increased commerce, trade, and property values and decreased costs may be difficult to predict or even to apportion afterward, but they are not the less influential in directing action. The vision of the men who built the Erie Canal was clearly verified by its benefits to the City and State of New York and to the Nation. It was not measurable by the financial return or by the amount of traffic. The variation of the summer and winter rates between Buffalo and New York is not forgotten to-day.

Some years ago, a locomotive was needed for construction work on the Columbia River, fifty miles east of Portland, Ore. It was ordered by wire and assiduously traced for prompt forwarding but, disregarding urgent requests for delivery, the railroad company carried it past its destination to Portland, whence it was returned three days later. This minor incident merely illustrates some features of the rail rate situation and their effects. The rail freight rate was the through rate to Portland, a water competitive point, plus the local rate back to the destination, and the railroad company felt impelled to justify the rate by actually making the haul. The entire question of transcontinental rates (to water competitive points) *versus* rates to intermediate points has since become well known through the Inter-Mountain Rates cases.

Water routes have not been developed or improved for the deliberate purpose of regulating rail rates, but they have had and still have the effect of bringing about a reduction of such rates to competitive points. Much of this benefit is almost ancient history, but even now the railroad companies are seeking a reduction in transcontinental rates to meet the competition of the improved water route through the Panama Canal.

With equality in rates for the line haul and with greater convenience in pick-up and delivery by the railroads through the admitted greater flexibility of rail terminals, it is to be expected that they will secure by far the greater part of the business at some competitive points. The waterways, however, have justified the public's confidence and willingness to spend its money on them,

although they may carry little actual commerce. To use a naval phrase, they have the value of a "fleet in being". Private operations over them may not be spectacular in tonnage or in financial returns, and Government operations, perhaps, may be expected to be even less so, but to illustrate general results by a specific case, the work on the Columbia River already mentioned has returned to the public many times the sums spent on it, although its traffic record is inconsequential compared to that of the parallel rail routes.

The speaker is far from advocating the reckless or extravagant expenditure of public funds on public works of any description. He does feel, however, that the improvement of water routes must not rest alone on the expectation of adequate direct financial returns to the owners of the utility—the public. Unimpeachable justification of the cost of such improvements by any possible economic analysis is not to be expected in the general case. Even judgment founded on long experience, observation, and study is not infallible. What is needed is some portion of that vision or second sight which is so uncommon among men of all classes, including engineers.

WILLIAM G. ATWOOD,* M. AM. SOC. C. E.—This paper performs two distinct and valuable services for transportation engineers. It collects and summarizes much scattered information regarding the design of waterways and waterway equipment, but, what is more important, it calls attention to some of the principles which should govern a decision as to whether a given transportation facility should be constructed and if so as to what form this construction should take.

Generally, transportation engineers have been and are specialists in railway, highway, waterway, or, more recently, air transportation, and many of them have been violent advocates of the type with which they are best acquainted. The development of the art of transportation makes it necessary that the engineer divest himself of any bias that he may have in favor of a single method of giving this service, that he attack the problem with an open mind and develop a co-ordinated system in which all methods may have a part. The services of specialists are still necessary after the general plan is adopted.

Custom and the basic characteristics of the different media have divided the transportation of the United States into two general classes; (1) Waterways and highways, generally constructed and maintained by some governmental agency, on which the traffic is moved by privately owned and operated equipment; and (2) railways where the all financing, construction, maintenance, and operation are privately performed and controlled, under Government regulation. The necessity for co-ordination in the design and operation of these two classes of facilities is only beginning to be generally appreciated.

Exceptions to these general classifications exist, such as the operation of an ocean fleet, of the Mississippi-Warrior River Barge Line, or the construction and operation of the Alaska Railroad by the Federal Government. Subsidies were also granted by the Government to the early transcontinental

* Cons. Engr., New York, N. Y.

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railways, by certain of the States to such roads as the Illinois Central, and the Nashville, Chattanooga, and St. Louis. The Cincinnati Southern was constructed and is still owned by the City of Cincinnati, and, many subsidies smaller in amount were given to the early railways by local governments and individuals, but the operation remained in private hands.

Conditions in other countries are quite different. In many of them not only are the waterways and highways built by the Governments, but the waterways are frequently, partly at least, Government operated, and, in many cases, the railways are both Government owned and operated. Under these conditions the co-ordination between the different methods of transportation is generally much better than in the United States.

General Black's rule that a transportation facility should not be constructed unless it will "produce an annual saving in the cost of transportation greater than the interest on construction plus maintenance and operating costs", seems to place an unwise restriction on construction. If a transportation facility will produce these results and promise a fair profit to its promoters, it will be constructed by private capital; but the development of a country may require the opening of transportation routes which will not fulfil these requirements.

At the time many of the early American railways and canals were built, they could not earn operating expenses, but the general good certainly justified their construction from a purely economic standpoint to say nothing of the political and cultural benefit which resulted. The development of the River Clyde, the construction of the Manchester Ship Canal and of the Panama Canal are other examples of expenditures fully justified by the general benefit which resulted, but which would not probably qualify under General Black's rule. In Europe the needs of the State, or what were thought to be such, also had their influence not only on the decision whether or not to construct, but on the selection of the type of facility and its design. For example, the railway system of the old Austro-Hungarian Empire was designed and built to centralize traffic in Vienna and Budapest for strategic reasons and in order to aggrandize those cities, although railways on more direct routes would have much better served the traffic needs of certain parts of the Empire.

In the case of privately owned facilities the user pays all the transportation costs, but with publicly owned facilities a part is paid by the user and the remainder by taxation. Eventually, these costs are paid in the cost of living by the general public and the construction seems to be justified if the sum of the tangible and intangible benefits equals or exceeds the cost. The construction or operation by governmental agencies of facilities which will qualify under General Black's rule will compete with private initiative and, therefore, are contrary to the principles on which the whole economic structure of the United States is built. Such methods are justified only when these requirements cannot be met and when it appears that intangible benefits of sufficient value will result.

After it has been decided to construct a new transportation facility, the selection of the type should be approached with more care and study than has

generally been the case. The advocates of the various types frequently omit pertinent items from their estimates and forget that the cost of moving freight begins in the warehouse of the consignor and ends in that of the consignee. The fact is also frequently overlooked that interest on the construction cost and the cost of maintenance of the waterway and highway (all of which are paid by taxation) are just as much a part of the cost of transportation as the same items, included in the railway rates. Too frequently these comparisons are made between the costs of moving a ton of freight after it is placed in the vehicle of the carrier. It is an unfair statement to say that waterway transportation is cheaper for a given 100 miles when the actual cost of moving the freight is 0.3 cent per ton mile by waterway, 0.9 cent by rail and 4.0 cents by highway, if the cost of delivery to and from the waterway and railway terminals and the terminal handling charges are, respectively, \$3.70, \$3.10, and nothing. High terminal charges have had a great influence on the decline in waterway traffic; conversely, the elimination of terminal charges in highway transportation is one of the reasons for its success.

Much of the argument in favor of waterways in the United States is based on European conditions without consideration of the differences in the history of the development of transportation on the two continents. In Europe, the first transportation was by waterway and highway. The industrial districts were developed so as to reduce terminal costs to a minimum, and these districts were built up solidly. When the railway arrived, it had difficulty in furnishing terminal facilities equally convenient for the industries. In the United States the industrial districts were built around the railways and now waterways are faced with terminal difficulties similar to those with which the European railways were confronted. These difficulties may and must be overcome in order to secure the most economical and efficient transportation system. Two examples may be cited.

The City of St. Louis originally depended on the Mississippi and Missouri Rivers for transportation, but its general industrial development followed and depended on rail transportation. To return a part of the traffic to the rivers has required the development of more economical vehicles, the construction of expensive river terminals, and the construction of interchange facilities between rail and water. Even then, many industries do not find water transportation economical, in spite of 20% lower rates, on account of the high cost of delivering freight to the water carriers.

In the days of Richelieu, La Rochelle, France, depended on water and highway transportation; the city walls enclosed the port. When the railways came, their terminals had to be located outside the walls and had no physical connection with the port. In order to "bring the wheels and keels together", it was necessary to construct an entirely new rail and water terminal and an industrial district 3½ miles away at La Pallice.

In the future, transportation engineers must see their problems on a larger scale than has frequently been the case in the past; they must always

have in mind the use of any or all the available methods of transportation and must not overlook the fact that co-ordination and co-operation of the various methods are necessary in order to give the best service for the lowest cost.

J. R. SLATTERY,* M. AM. SOC. C. E.—Underlying this demand for the improvement of internal waterways—and it is a real demand—lies a condition exemplified by a few rail rates which will be quoted. These rates are not from the latest rate tables and, therefore, may differ somewhat from actual present rates. From Cincinnati, Ohio, to Evansville, Ind., on the Ohio River the distance is 270 miles; from Cincinnati to Gallatin, Tenn., which is inland, the distance is 273 miles. The rates to Gallatin are from 28.4 cents to 36.0 cents higher per 100 lb. than those to Evansville. From Pittsburgh, Pa., to Cairo, Ill., at the junction of the Ohio and Mississippi Rivers, the distance is 693 miles and from Pittsburgh to Dalton, Ga., an inland point, the distance is 689 miles. The class rates per 100 lb. from Pittsburgh to Dalton are from 31.5 cents to 63.5 cents higher than to Cairo. Innumerable other examples of such differences in rates between river points and inland points the same distance apart could be quoted.

In urgent demands that come before the U. S. Board of Engineers for the Improvement of Waterways, the claim is almost invariably made that such improvement would result in material savings in freight cost; possibly underlying this demand is the hope that the improvement will bring about a reduction in rail rates between points on the waterway, which very often happens after its completion. It is possible that in some cases the advocates of improvements are more interested in securing a reduction in rail freight rates than in actually securing service by boat.

There is some reason to think that if rail rates were based primarily on the length of haul with, of course, proper allowances for terminal charges, the conditions of the waterways would be very different from what they are. There are many who think, not without reason, that the establishment of uniform rates for certain lengths of haul regardless of whether the points between which the haul is made are water points or inland points, would result in a vast fleet of boats on American waterways.

Mr. Markham has brought out clearly the small use that is being made of some improved channels and the losses that have been incurred in attempting to operate boat lines on them. It would be interesting to determine how great the return on the investments in waterways would be, if to their account were credited the lower freight rates allowed by railroads on hauls between points along the stream. A vast trade moves by rail along many of these waterways between water points and on such freight a vast sum of money is saved through the lower rates allowed.

The Engineer Department of the Army has never favored using a waterway merely to pound down freight rates, but there is a strong sentiment urging that very thing.

* Lt.-Col., Corps of Engrs., U. S. A.; Dist. Engr., First Dist., New York, N. Y.

C. I. GRIMM,* Assoc. M. Am. Soc. C. E. (by letter).†—In speaking either of waterway or of railroad transportation in general terms, a wide range is included and the author has covered fully the general aspects of the subject. A specific comparison of transportation on a particular kind of waterway with transportation of the same commodities by rail is the problem that generally has to be considered by those who are studying the advisability either of improving waterways or of using waterways already improved. The main purpose of this discussion is to present such a comparison in a field that is now of sufficient interest to warrant considerable attention.

The author recognizes that interest charges on the cost of an improved waterway as well as the expense of maintenance and operation, even though paid from the National or State treasury, are a proper charge against the cost of transportation—a premise which should be generally accepted. If a large tonnage is carried, these charges are relatively small for waterways such as the Great Lakes and for non-canalized navigable rivers such as the Lower Mississippi, but quite appreciable for canalized rivers; whereas for canals with numerous locks they may easily exceed the carrying cost of all traffic on the waterway until the time when this traffic approaches the limits of capacity.

Specific comparisons of rail and water costs for the coal and ore movement on the Great Lakes are hardly necessary to demonstrate the economy of lake transportation; on the other hand, it is generally true that purely artificial canals with numerous locks do not compare favorably with railroads, and that their construction is advisable, if at all, only where they form a short connecting link between waterways that afford more favorable conditions for transportation and that have a large existing or prospective traffic in bulk freight. In view of the foregoing and of the fact that at present the navigable inland waterways of the United States consist largely of canalized and non-canalized rivers permitting drafts of 6 ft. to 9 ft., comparisons between transportation on such waterways and on railroads are of particular value; and as the principal tonnage on these waterways is coal, this discussion will be limited to consideration of the transportation of coal on a canalized river, as compared with railroad transportation. It is understood that what applies to coal applies to any similar commodity that might move in equivalent quantity and in carriers of the same type.

The method of transporting coal by river is almost exclusively in groups of barges with capacities of 500 to 1 000 tons, pushed by towboats. The larger sized barges are more economical to operate where large tonnages are handled and a draft of 8 ft. or more is available.

The dead weight of steel barges with capacities of 500 to 1 000 tons is approximately 20% of their live load capacity, or 400 lb. per ton of capacity. For steel coal cars this percentage is about 40%, equivalent to 800 lb. per ton of capacity. The cars will cost somewhat more per unit of dead weight than the barges. At present prices barges will cost not more than \$20 per ton of capacity, whereas coal cars will cost at least \$40. Modern towboats

* Asst. Engr., U. S. Engr. Office, Cincinnati, Ohio.

† Received by the Secretary, November 14, 1924.

capable of towing 6 000 tons at 5 miles per hour and having a tractive capacity of 3½ lb. per ton of cargo will cost approximately \$30 per ton of cargo capacity.

The prevailing practice on a number of important coal roads provides a tractive capacity of about 20 lb. per ton of cargo. The cost of the locomotive required, with its tender, is about \$1 per lb. of tractive capacity, or \$20 per ton of cargo capacity.

Considering the relative speed of railroad and waterway equipment, it would seem, on first consideration, that barges and towboats, as their speed is much less, would travel a much shorter distance per year than locomotives. As a matter of fact, however, this is not true in practice, as the time used in transit is a small percentage of the total time and the less congested terminal conditions on waterways involve less terminal delays. Furthermore, barges and towboats are delayed less for ordinary upkeep service and repairs.

Freight-car performance on coal roads having short hauls is as low as 10 miles per day, while for average hauls (250 miles) it is about 25 miles per day. The cars are moving therefore only 1 or 2 hours per day, while a barge to accomplish the same result would have to work from 2 to 5 hours, an easy accomplishment by reason of lesser delays at terminals.

Actual comparison of railroad and waterway movements for comparable distances indicates that barges will make an annual mileage comparable with that of freight cars and that annual towboat mileages will be about 75% of freight locomotive mileages, the annual travel of which is about 25 000 miles.

The relation of the principal items that make up the cost of transportation both by water and by rail, exclusive of fixed charges on the thoroughfare, and an estimate of the amount of each for a specific movement is shown in Table 3. These costs presuppose a large tonnage, a steady movement, and no return cargo, the latter condition being usual for coal transportation either by rail or by water. It is assumed also for the waterway that it will be open to navigation for the full year except for such interruptions as will occur from high water. The assumed length of haul (250 miles) approximates the average haul for railroads serving the large coal fields of West Virginia and Kentucky. The costs of equipment are based on the previously stated estimates of unit costs and annual mileages. The costs of the various items under "Haulage" are consistent with actual costs obtained from a study of statistics of both rail and water transportation, those for railroad transportation having been obtained from "Statistics of Railways" for 1922, as prepared by the Interstate Commerce Commission.

A condensed statement of the railroad statistics analyzed is given in Table 4. This analysis covers important railroads whose principal tonnage is coal or iron ore and whose passenger traffic is relatively light. Railroad transportation costs, as published in the Interstate Commerce Commission report referred to, do not distinguish between freight and passenger costs and it is necessary, therefore, in separating these costs to make assumptions which introduce some error into the costs assigned to freight transportation. This error, however, has been minimized by selecting roads having a minimum percentage of pas-

senger service. The railroad haulage costs given in Table 3 for the first two items are obtained by taking the indicated percentage of the estimated cost of new equipment, as given in the upper part of the table, while the other items are from Table 4 for the railroad having minimum cost. If the average of the five railroads is used, the total haulage cost by rail is 4.80 mills per ton-mile instead of 3.86 mills.

TABLE 3.—COST OF EQUIPMENT AND HAULAGE. COMPARISON FOR RAILROAD AND CANALIZED RIVER.

(Charges on Thoroughfare not Included).

EQUIPMENT.						
Basis of cost of equipment.	WATERWAY.			RAILROAD.		
	Barges.	Towboats.	Totals.	Cars.	Locomotives.	
Per ton of capacity.....	\$20.00	\$30.00	\$50.00	\$40.00	\$20.00	\$60.00
Per ton of annual capacity.....	0.84	0.84	1.68	2.00	0.60	2.60
Per ton-mile per year.....	0.0033	0.0083	0.0067	0.0080	0.0024	0.0104
HAULAGE.						
Items of operating costs.	WATERWAY.			RAILROAD.		
	Cents per ton.	Mills per ton-mile.		Cents. per ton.	Mills per ton-mile.	
Interest on equipment, 6%.....	10.10	0.40	15.8	0.63		
Depreciation on equipment.....	5.05	0.20	7.75	0.31		
Maintenance of equipment*	10.0	0.40	33.2	01.33		
Fuel.....	5.0	0.20	8.5	0.34		
Crews.....	15.0	0.60	9.25	0.37		
Yard and station employees.....	5.0	0.20	6.0	0.24		
Superintendence, general expense, insurance, taxes, dispatching, loss, damage, supplies and miscellaneous.....	12.5	0.50	16.0	0.64		
Totals	62.65	2.50	96.5	3.86		

NOTES.—Costs based on hauling coal 250 miles, no return cargo. Waterway: 6 000-ton cargos in 1 000-ton barges, 9 ft. 0-in. draft, wide river, large tonnage and steady movement. Railroad: 3 000-ton train loads in 50-ton cars, favorable grades and curves, large tonnage and steady movement.

* Calculated as sinking fund for replacement in 20 years.

For either a waterway or a railroad the ton-mile cost of interest and maintenance for the thoroughfare will vary inversely with the density of traffic. For the five railroads the costs of which are analyzed the average maintenance charge is 0.81 mill per ton-mile. The average annual traffic density of these roads is about 4 000 000 ton-miles per mile of main track. In view of the fact that these roads have considerable double track, this is regarded as a reasonably high traffic density for roads operating both freight and passenger service.

The "book value" of these roads has been published by the Interstate Commerce Commission,* but as this value includes equipment and facilities for

* "Statistics of Railways," 1922.

passenger service, the valuation chargeable to freight transportation cannot be closely determined from these statistics, neither can it be said that the valuations given are equitable. However, by subtracting from the valuation estimated as assignable to freight transportation the estimated value of freight equipment, the value per mile of main track has been approximated. The interest cost per ton-mile under these assumptions has been estimated; for the five roads it averages 1.1 mills or \$4 400 per mile of main track for the average annual traffic density of 4 000 000 ton-miles per mile. For a 6% return this corresponds to a valuation of approximately \$75 000 per mile, a figure which is consistent with averages for the Eastern District and with more specific cost data for roads having comparable physical features. Their average estimated charge for interest and maintenance of way is 1.81 mills per ton-mile, which figure might be reduced somewhat, under favorable conditions, for a railroad built exclusively for freight, but which is regarded as a fair average cost chargeable to the transportation of coal or similar bulk commodities.

TABLE 4.—CONDENSED STATISTICS OF IMPORTANT FACTORS AFFECTING COST OF FREIGHT TRANSPORTATION AND ESTIMATE OF COST OF FREIGHT TRANSPORTATION ON FIVE RAILROADS.

(Costs given in Mills per Ton-Mile.)

	Railroad No. 1.	Railroad No. 2.	Railroad No. 3.	Railroad No. 4.	Railroad No. 5.	Average.
Mine products, percentage of total tonnage.....	92	90	83	80	79	.....
Ratio of passenger service revenue to total operating expenses, percentage.....	8.0	5.2	12.0	17.0	19.4	.....
Operating ratio, percentage.....	65.44	69.46	77.57	75.27	79.17	73.40
Cars loaded, percentage.....	53.0	68.0	59.0	59.0	60.0	.....
Average haul, in miles.....	342	109	117	279	263	.....
Average loaded car load, in tons.....	57.1	49.7	45.3	41.5	41.5	.....
Average miles per day for freight cars.....	24.6	9.6	11.1	26.4	22.7	.....
Average tractive power of locomotives, in pounds.....	69 500	43 700	45 500	50 000	46 000	.....
Average train load, in tons.....	1 800	1 401	1 480	1 127	1 254	.....
Ton-miles per annum.....	2 639 000	1 809 000	1 518 000	11 097 000	10 519 000	.....
Ton-miles per mile of main track.....	4 650 000	4 760 000	3 550 000	3 825 000	3 220 000	4 001 000
Value of equipment per ton-mile						
Locomotives.....	2.19	3.03	2.98	2.72	2.29	2.6
Cars*.....	6.25	12.5	12.3	7.10	7.72	9.2
(1) Interest on equipment at 6%†.....	0.42	0.78	0.76	0.49	0.50	0.71
(2) Interest on road at 6%†.....	1.94	0.88	1.01	0.89	0.80	1.10
(3) Depreciation on equipment.....	0.20	0.40	0.38	0.32	0.23	0.31
(4) Maintenance of way and structures.....	0.76	0.70	0.85	0.93	0.80	0.81
(5) Maintenance of equipment.....	1.33	1.55	1.98	1.50	1.63	1.60
(6) Fuel for locomotives.....	0.34	0.54	0.67	0.45	0.52	0.50
(7) Train crews.....	0.37	0.47	0.48	0.47	0.48	0.45
(8) Yard and station employees.....	0.24	0.44	0.91	0.52	0.54	0.53
(9) Superintendence, general expense, traffic dispatching, loss and damage, insurance, supplies.....	0.64	0.98	0.77	0.73	0.82	0.78
(10) Total of Items (3) to (9).....	8.88	5.08	6.02	4.98	5.02	4.98
(11) Average receipts.....	6.70	7.76	7.84	7.45	6.86	7.32
(12) Available for Items (1) and (2) (Item (11) less Item (10)).....	2.82	2.73	1.82	2.52	1.84	2.34
(13) Estimate for Items (1) and (2).....	2.36	1.66	1.77	1.38	1.30	1.81

* Estimated at 75% of cost of new equipment.

† From estimated valuation.

A river well suited to canalization with modern locks adapted for coal tugs may cost at present prices from \$50 000 to \$150 000 per mile, and such a river would have a capacity of more than 10 000 000 ton-miles per mile. The cost of canalizing the Ohio River will be nearly \$110 000 per mile. In general, the cost of a canalized river will be less than that of a railroad of equal capacity, but if the traffic density is low, a railroad which will handle a light traffic may be built at a first cost less than that of improving the river and may be expanded as traffic develops, the cost eventually reaching a figure equal to or greater than that of a canalized river of equal capacity.

The Monongahela River, which is improved for a distance of 125 miles, has a traffic density in the lower 60 miles of 20 000 000 ton-miles per mile, or nearly 10 000 000 ton-miles per mile considering its entire improved length. The cost of interest, maintenance, and operation does not exceed 1 mill per ton-mile as compared with 1.8 mills per ton-mile for the five railroads in Table 4. The annual interest, maintenance, and operation charges for the Ohio River will approximate \$9 000 per mile, assuming the same rate of interest (6%) as previously used for the railroad estimate. With a traffic density of 5 000 000 ton-miles per mile, the fixed charges will be 1.8 mills per ton-mile, a figure comparable with railroad costs of interest plus maintenance. The capacity of the river is from five to ten times this traffic density; if it reaches even 10 000 000 ton-miles per mile, the fixed charges carried by the Federal Government are estimated to become less than 1 mill per ton-mile.

The foregoing estimates indicate that there are possibilities in improved rivers which are well worth considering by shippers of large tonnages of bulk freight under conditions where terminal costs compare at all favorably with those of rail shipment.

H. F. DUNHAM,* M. A. M. Soc. C. E. (by letter).†—In a synopsis and paper so comprehensive and far reaching it is difficult to discern all of the ideas and thought relations in the mind of the author. One should realize that from the first pioneer highway that connected two coast villages about 1635 to the largest modern transportation problem the effort has been unremitting “to secure an exercise of unprejudiced judgment” before making large expenditures. Efforts to this end in the distant past have been, and in the present are, hedged about with difficulties, of which three may seem worthy of further analysis than the author has given.

The element of time causes many departures from an expected and approved course. In illustration, two rival railway companies may be cited: Each determines to secure control of certain terminal rights or of locations in the mountains before the other can acquire them. Vast expenditures, unwarranted by the physical conditions, are then made. To say there should be no such rivalry does not prevent its existence or its appearance at any period. To say the railroads should be under different control is also futile as shown by attempts to build subways in New York by the importance of time in Wall Street and in Washington as well, where the *Congressional Record* relates that

* Civ. and Hydr. Engr., New York, N. Y.

† Received by the Secretary, December 17, 1924.

scores of millions were saved through the defeat of a Federal waterway bill, by a Congressman who continued speaking without interruption for two days more or less or until the final adjournment of that session. Truly time is a factor in the affairs of men and of governments.

The second feature, that of enhanced values, is the effect of new enterprises on real estate and other interests. Trenching for canals could have been accomplished, hundreds of miles of railroad could have been graded and the superstructure provided, all by outside parties having no other interest than that of avoiding a few years of delay in the arrival of the first canal boat or the first steam train; it would have been good real estate business in those early days, but co-operation was less common then and the men and the prairies had to wait. To-day in city planning and development, like principles and their effects may be noted.

A third element is found in the phrase "political divisions". For nearly a hundred years there have been engineers in the United States competent to locate a railway to connect St. Paul, Minn., with the Great Lakes. There were no large rivers to cross; there was the wonderful harbor of St. Louis Bay, bordered on the south by a level plateau, 40 ft. above Lake Superior—the ideal site for a city of millions. But what is found there to-day? A railway following down the tortuous left bank of the St. Louis River to a city on the side of a mountain 500 ft. high and so steep as to be hardly habitable, with sewers and water and gas mains embedded in solid granite—a city practically without harbor facilities until decades of legal and physical battle secured them. Why all this needless expense and confusion? Simply because it was set forth in the charter for a railway from St. Paul to the Great Lakes that every foot of the roadbed should lie in the State of Minnesota.

This may be called an extreme case, but it is the "extremity" in each case which shows how fundamental and unchangeable are the involved principles and how they interfere with the best of theoretical conclusions and readily formulated ideals.

WILLIAM H. BURR,* M. AM. SOC. C. E. (by letter).†—In discussing General Black's paper, the writer has no other purpose in view than a general engineering consideration of the subject. He does not believe that the construction or operation of a limited waterway, more or less parallel to a railroad, can seriously affect the freight business of that railroad except under such extraordinary conditions as those exemplified by the Panama Canal, or the St. Mary's Canal. In cases like the Barge Canal in the State of New York, it is feasible for a limited waterway to stimulate the growth of a profitable business without trenching on the established business of a parallel railroad. In order to do that, however, the carriers must be so designed and built, and be so equipped with power, as to meet the economic requirements of the situation. Unfortunately, neither the Federal Government, nor a State Government, has yet shown evidence of the requisite business capacity to administer successfully such an undertaking, in so far as the public interests may require.

* Cons. Engr., New York, N. Y.

† Received by the Secretary December 26, 1924.

General Black's paper sets forth some of the fundamental elements of limited waterway transportation which have not heretofore been so well reduced to a quantitative basis.

All the elements of railroad transportation have been known and computable, so to speak, for years, but water transportation in limited waterways has not been subject to such quantitative treatment. In other words, canals and similar limited waterways have been fitted with boats designed and built to meet purely local conditions without regard to economic principles, either as to transportation resistances, or as to the economic effect of the dimensions of the waterway on transportation costs. One of the fundamentally valuable features of this paper is the setting forth of economic elements of the broad problem in such manner that a limited waterway transportation project may receive the same analytic consideration as a railroad project.

As the first result of these considerations, apparently the author would make the decision as to whether a transportation project should be approved and actually constructed, by the aid of its purely analytic features. At the very outset of the paper he states:*

"New waterway lines of transportation should not be established unless an analysis of the existing railway, highway, and waterway lines and of the need for transportation shows that the proposed new line is required and that if established it will produce an annual saving in the cost of transportation greater than the interest on construction plus maintenance and operating costs."

To base the inception and actual construction of a railroad on the estimated profits which it may earn, is, of course, an old method of procedure, although in the early days of railroading it was not easy to predetermine by any well-defined considerations of cost, or contemplated business, whether or not a road would pay. In fact, it has been said many times that the proper time to build a given railroad line was whenever sufficient money could be raised to do it. As a consequence, many new railroad lines were built before it was possible to secure a profitable business. The individuals who placed their money in the project lost at least part of that which they expended, but the general wealth of the community was increased.

As a broad proposition, therefore, the building of the railroad was justified by the favorable effects on the community as a whole, although the effect on some individuals was ruinous.

Similarly, if the attempt should be made to control the construction of waterway transportation by the same method of estimating costs and profits in order to determine whether or not the project should be undertaken, it would be found impossible in many and perhaps most cases, to predict, first, how much business would result and, second, what actual transportation costs would be after the transportation lines were built. In fact, there would undoubtedly be the same result as in the case of so many railroad projects.

Again, a complicating question would undoubtedly arise especially under present conditions, in consequence of limited Federal control of the transportation business. Who would constitute the deciding body as to whether the con-

* *Proceedings, Am. Soc. C. E., August, 1924, Papers and Discussions, p. 837.*

ditions were sufficiently encouraging to undertake the project? Such a body would have a highly complicated problem to solve. The cost of transportation, as indicated by the author, would involve the costs required to overcome the resistance of the water against the moving boat, a resistance varying with the surface and form of the boat and the dimensions of the waterway, also with the kind and cost of power as well as the speed of the boat, and with other elements of the problem less adapted to definite treatment.

In addition to the various elements of cost there would be that of the actual construction which might be reasonably determinable in some cases and quite impossible of accurate determination in others. While such elements of the broad question may be, and are indeed, subject to some degree of definition, they certainly cannot be determined in advance within any such close limits as to make a reasonable basis for determination of profits.

There is, however, another source of uncertainty of the highest importance, and that is the probability of securing the requisite capital to make the project a reality. No ascertainment of cost of any kind, whether of construction, of equipment, or of transportation, can be considered sufficient for bringing success to the project unless the owners of the necessary capital are convinced that the project will be successful from a business point of view. In fact, that is the last and principal condition on which the project can be put through successfully. It would matter little what any lawfully organized body, or even disinterested experts, might decide. In fact, it comes down to the old criterion under which railroads and other projects have been carried through; if capital can be interested the project may be realized, but not otherwise. It is, therefore, scarcely feasible to subject the existence of future extension of the business of transportation in limited waterways to the test of whether or not they can be built and operated profitably. If one stops to realize that what communities are looking for, after all, are those developments which will increase their total wealth, carrying with it, on the whole, individual wealth, it will be seen that any test more or less artificial in its nature, and thus indeterminate, is both unnecessary and in reality unadapted to secure desirable results.

The résumé given by the author of formulas and authorities relating to channel dimensions, types of carriers, and features of propulsion of boats, as well as to costs of transportation is excellent and useful. It is not to be supposed that it indicates a complete solution of problems undertaken by the various authors named. The results are far indeed from that. They do indicate, however, a rational beginning with sufficient data on which to base at least some approximate conclusions as to the design of boats, the relation of their cross-sections to that of the waterway, the amount and character of some resistances, and the variable elements on which the amounts of those resistances rest.

Other experimental investigations of the same character will doubtless continue to be made from time to time, constantly improving designs and correspondingly reducing resistances as well as furnishing data for the improvement in power. There is no reason why all these variable elements of limited waterway transportation should not ultimately be as well controlled as the

elements of railroad transportation. Such ends must be attained if canal transportation is to come to its own in the United States or any other country.

Whenever the Barge Canal of the State of New York attains the position of a carrier of respectable tonnage, all the data available will be required to design proper boats, effective motor power, and to determine at least approximate resistances. This waterway, having a minimum width of bottom of 75 ft., and in the canal proper a depth of 12 ft., but with a depth of 14 ft. over the lock sills, should have an annual capacity of 20 000 000 tons, whereas during the canal season of 1924, its total traffic was only 2 032 317 tons, the highest amount reached since its completion. The commodities showing the greatest tonnage this season were petroleum and other oils, paper and paper products, and wheat. The tonnage of local traffic was 520 525, about one-quarter of the total. On the whole, such boats were used as could be found; however, the Standard Oil Company and other companies used special boats adapted to their purposes.

The total expenditures made by the State of New York on this project from the inception of the old Erie Canal to and including the Barge Canal in its present condition, have been approximately \$220 367 600. Before the Erie Canal was made free, however, in 1882, it had earned and paid back to the State of New York the net sum of \$93 342 000, leaving the net total expenditure at the present time of \$127 025 600. This looks discouraging for canal business, but there probably never was a great business project treated with so little business wisdom, with scant consideration of any of its real problems, or with such absence of intelligent interest as this great transportation property. After the canal itself had been well constructed, it was, figuratively speaking, treated with silent contempt and neglect, and has gradually come to be regarded as about the strongest argument available against any attempt to make a limited waterway successful, even under the most favoring conditions.

As a matter of fact, the Panama Canal has been a phenomenal success and will always remain so, likewise the St. Mary's Falls Canal. Although those canals are, of course, extraordinary cases, the general proposition holds that limited waterways, equipped with properly designed boats and suitable power and apparatus for handling cargo at terminals, should be classed as among those effective means of transportation on which the growth of communities is based.

Memoirs.

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MEMOIRS OF DECEASED MEMBERS

NOTE.—Memoirs will be reproduced in the volumes of *Transactions*. Any information which will amplify the records as here printed, or correct any errors, should be forwarded to the Secretary prior to the final publication.

JOHN AUGUSTUS OCKERSON, PAST-PRESIDENT, AM. SOC. C. E.*

DIED MARCH 22, 1924.

John Augustus Ockerson, the son of Jans and Rose Jans Datler Akerson, was born on March 4, 1848, at Slattarod, Province of Skane, Sweden.

When two years of age he was brought by his parents, with their other children and some relatives, to the United States. While journeying West in an emigrant wagon, both parents and the oldest son died of cholera just before reaching Chicago, Ill. The remainder of the family proceeded in the care of their relatives, who settled near Elmwood, Ill., where young Ockerson grew to manhood, attending the public schools and the Elmwood High School, finally matriculating in the State University.

In Sweden, the name is spelled Akerson, but on coming to America, the family expressed the Swedish pronunciation in English by spelling it Ockerson.

When only sixteen years of age, but passing for eighteen, young Ockerson was mustered into the United States Military Service for the Civil War, at Elmwood, on June 1, 1864, as a Private in the 132d Illinois Infantry, but was mustered out with his Company on October 17 of the same year. However, at Red Wing, Minn., on January 30, 1865, he re-enlisted, this time in the 1st Minnesota Heavy Artillery and served until September 27, when he was mustered out with his Battery.

In the fall of 1869, he entered the University of Illinois, then known as the Illinois Industrial University, and while pursuing his studies there, took an active part in student and university affairs. During the summer vacation of 1871, he was engaged as a Recorder on the survey of the Great Lakes (U. S. Lake Survey), and during the vacation of the following year was a Levelman on location for the Atchison, Topeka, and Santa Fé Railroad. He was graduated in 1873 from the course in Civil Engineering, receiving the degree of Bachelor of Science, and subsequently that of Civil Engineer. Thirty years later, his Alma Mater conferred on him the honorary degree of Doctor of Engineering. The title, "Colonel", frequently applied to him was only by courtesy, but was never pleasing to him.

From 1873 to 1878, Mr. Ockerson was again employed on the survey of the Great Lakes, with the title of Assistant Engineer, being engaged in topographic and hydrographic surveys, in triangulation, and the measurement of primary base lines. During this period he was for a time, in 1876, Government Inspector on the survey for the Eads jetties at the mouth of the Mississippi River.

In 1879, he was transferred to the newly created Mississippi River Commission, and, until 1887, was Principal Assistant Engineer in charge of sur-

* Memoir prepared by the following Committee: I. O. Baker, J. W. Skelly, and Wm. S. Mitchell, Members, Am. Soc. C. E.

veys and physical examinations from the head-waters of the river to the Gulf of Mexico.

In the latter year, Congressional appropriations for rivers and harbors having been greatly reduced, Mr. Ockerson left the service of the Commission, and was engaged, from 1888 to 1889, as Manager of a gold and silver mine in Colorado. In 1890, he returned to the Mississippi River Commission and served as its Principal Assistant Engineer until 1898, when, by appointment of President McKinley, he became a member of the Commission, in which position he remained for twenty-six years, until his death. He took an active part in its deliberations and in the direction of all work in its charge. During his later years of service, in recognition of his ability and thorough knowledge of the work of the Commission, he was usually Chairman of its leading committees, those on design and construction of levees, of hydraulic dredges and dredging, of bank protection, etc.

The Commission maps of the river, made by him and under his direction are exceptionally full and accurate, and are in great demand both in this country and abroad.

In the later years of his life, Mr. Ockerson was active also as a Consulting Engineer, serving in advisory capacity on many important works, including the Chicago Drainage Canal, in 1907; Big Wood River Dam in Idaho, in 1909; East Side Levee and Drainage District, East St. Louis, Ill., from 1908 to 1912; Little River Drainage District, Missouri, in 1914; and Conservancy District, Miami Valley, Dayton, Ohio, in 1914.

Perhaps his most outstanding individual work in engineering was the building of levees along the Colorado River in 1910, to hold back its flood waters which threatened to overflow into the Salton Sea. He was appointed by President Taft, late in the summer of 1910, to have charge of the work for which Congress had recently appropriated \$1 000 000. The work was difficult and trying owing to the light silt soil on which the levee was founded, and to the necessity of haste to finish before the season of floods, and, further, to the fact that the work was to be done on the Mexican side of the International Boundary, with teams, tools, materials, etc., from the American side, to protect settlers and property in the United States, which introduced serious complications in the Customs regulations. The regulations of the United States Government concerning the expenditure of public funds so seriously hampered the work, in which expedition was vital, that, at times, it became necessary to telegraph to the Interior Department at Washington, to ask the State Department to request the Government of Mexico to authorize the Mexican Customs Officials to permit the entrance of emergency supplies, and then to await reply through the same circuitous route. In addition, the Indian inhabitants of the adjacent Mexican territory were in active insurrection, and the Republic of Mexico itself in the throes of revolution. For this work, Mr. Ockerson received the personal commendations of President Taft for his "pertinacity under the most trying circumstances."

At the Louisiana Purchase Exposition in St. Louis, from 1904 to 1905, Mr. Ockerson was Chief of the Department of Liberal Arts, and also was a

member of the Superior Jury of Awards. He had been previously a member of the International Jury of Awards of the Paris Exposition in 1900.

His study of river improvements and related features took him to Europe on three Government investigations of waterways and seaports. He was an official delegate of the United States to four International Navigation Congresses.

At the St. Louis Exposition, and on his European trips, Mr. Ockerson received honors and decorations from many foreign Governments, among which were Officer de l'Instruction Publique, and also Merit^e Agricole (France); Knight of the Crown (Italy); Knight and also Commander of the Order of Vasa (Sweden); Knight of the Crown (Germany); Knight of the Order of Leopold (Belgium); Officer of the Order of the Double Dragon, first grade (China); and a silver medal for special services, from Russia. Because of his official position on the Mississippi River Commission, under the law, he could not accept the insignia of these orders, and they were left, until after his death, in the custody of the State Department in Washington.

Mr. Ockerson was the author of numerous official technical reports from 1881 until his death. Many of his papers and discussions have been published in the *Transactions* of the Society, in the *Journal* of the Association of Engineering Societies, and in various other engineering periodicals. He contributed papers to the *Proceedings* of the International Congresses of Navigation at Paris in 1900; at Milan in 1905; at St. Petersburg in 1908; at Philadelphia in 1912; and to the Engineering Congress at Glasgow in 1901. He was intimately identified with early experiments in hydraulic dredging and his first and elaborate report on that method of opening and maintaining channels for navigation in rivers, has been a milestone in engineering history. His long association with, and personal knowledge of, the Mississippi River, as well as his many clear, forceful, and instructive writings, gave him an eminent position among civil engineers engaged in river regulation in both this country and in foreign countries.

He died at his home in St. Louis, and was laid to rest in Bellefontaine Cemetery in that city.

Mr. Ockerson was married on November 3, 1875, at Detroit, Mich., to Helen M. Chapin, who died in March, 1886. On June 4, 1890, he was married to Clara W. Shackelford, of St. Louis, Mo., who survives him.

He was twice Vice-President and twice President of the Engineers' Club of St. Louis, and was a member of the Grand Army of the Republic, of several social clubs, and of various civic organizations.

In person, Mr. Ockerson was tall and handsome, with a dignified and quiet grace of manner. He was affable, easily approached, and in public spoke readily with clear and forceful expression. He will continue to live in his writings, and especially in his labors for the advancement of engineers, and his life-long efforts for self-improvement will stand as an inspiration to worthy young Americans.

Mr. Ockerson was elected a Member of the American Society of Civil Engineers on June 7, 1880. He served as Vice-President of the Society in 1907-08, and as President in 1912.

GEORGE HENRY PRESTON, M. Am. Soc. C. E.*

DIED MARCH 17, 1924.

George Henry Preston, the son of G. H. Preston and Julia D. Preston, was born in Dansville, N. Y., on June 8, 1879. He was denied the advantages of a college education, but this loss was largely made up by close application in various positions which he held as a newspaper reporter, in business, and in engineering work. He attended the High School at Wilkes-Barre, Pa., for about two years, pursuing at the same time a night course in the Young Men's Christian Association. His work there attracted the attention of Mr. J. H. W. Hawkins, a local architect, who employed him as an Apprentice and Draftsman for about a year.

Mr. Preston's inclination led him to seek work of an engineering nature, and he obtained a position as Rodman in the Engineering Corps of the Lehigh and Wilkes-Barre Coal Company, which he held during 1898.

From 1899 to 1901, Mr. Preston was with the Electric Testing Department of the Hazard Manufacturing Company, Wilkes-Barre, in charge of repairs, insulated wires, and cables. The following year he worked as Draftsman and Checker with the Phoenix Iron Company, at Phoenixville, Pa., and, in 1903, was with the Baltimore Bridge Company as Draftsman in charge of structural detailing. For two years, 1903-1905, he was employed by the Cambria Steel Company at Johnstown, Pa., in the Structural Department in charge of detailing steel work.

At this juncture, it became his lot to assume the control of the Seward Coal Company and the Seward Brick Company of Johnstown, as President and General Manager, and for four years he carried on this business with much skill in the doubly difficult capacity of administrator and official. After this work was completed in 1909, he returned for a year with the Cambria Steel Company as a Designer.

Mr. Preston then turned his attention to the field of concrete engineering, working on general building construction with the Turner Construction Company for about eleven years, from 1909 to 1921, progressing through the various grades in the Engineering Department to that of Assistant Engineer. During the early part of this period, he took a special course in concrete engineering at Columbia University.

For a short time in 1911 he undertook a special type of engineering work in New York, N. Y., for the Otis Elevator Company, in charge of the design of air cushions and special foundations for the Woolworth Building and with N. M. Andrews, Architect, in charge of the design of the foundations for the Equitable Building.

In 1922, Mr. Preston was in business as Consulting Engineer, and in a few months had successfully established a working clientele, but, receiving an offer from John Ferguson Company, Builders, of Paterson, N. J., he accepted the position of Engineer, which he held until his death.

* Memoir prepared by H. C. Paddock, M. Am. Soc. C. E.

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Mr. Preston was an Engineer by nature and by practice. He had an exceptionally ingenious mind and was clever in solving difficult engineering problems. As a man, he was much loved by his associates, and is remembered as one who was always willing to impart his knowledge to those anxious to learn.

One of his characteristics was his love of a joke, but his pleasure was not the less when the joke was on himself. Of an even disposition and always courteous, he held the esteem of all who knew him. Although of a jovial nature, he was conscientious almost to a fault, and it was this characteristic, no doubt, that contributed largely to his death. Being in a run-down physical condition, he did not have sufficient vitality to withstand an attack of pneumonia, to which he succumbed after a week's illness.

He is survived by his wife, who was Lucy Brown, of Johnstown, Pa., together with a daughter and a son.

Mr. Preston was elected an Associate Member of the American Society of Civil Engineers on April 4, 1911, and a Member on November 21, 1921.

JOHN CRESSON TRAUTWINE, JR., M. Am. Soc. C. E.*

DIED JULY 4, 1924.

John Cresson Trautwine, Jr., the son of John Cresson and Eliza Ritter Trautwine, was born in Philadelphia, Pa., on March 17, 1850.

He was educated in the public schools, and was trained in commercial work in the employ of a firm of iron brokers, Morris Wheeler and Company, and then in the service of his father whom he assisted for several years in the exacting and painstaking work of revising and editing the "Civil Engineer's Pocket-Book."

Collaborating with the late Rudolph Hering, M. Am. Soc. C. E., in 1887, Mr. Trautwine translated Ganguillet Kutter's "Flow of Water in Channels". In 1890, with Arthur Marichel, he translated parts of H. Bazin's "Flow of Water over Weirs" and in 1904, he collaborated with Olga and Boris Simin in the production of their paper on "Water Hammer".†

For twelve years he was Secretary of the Association of Engineering Societies and Editor of its *Journal*, and for four years held the position of Chief Engineer of the Bureau of Water of the City of Philadelphia. At intervals, from 1892 to 1907, he served that city on Civil Service Boards in the examinations of candidates for municipal engineering positions.

In his consulting practice, Mr. Trautwine covered a wide range of engineering activity, bringing to the service of his clients deep technical knowledge and sound practical judgment. Acting either individually or on commissions, he investigated, reported and advised on many engineering projects, including a water distillation plant at Pittsburgh, Pa.; the location of an electric car line in Northeast Philadelphia; the condition and utilization of various leased lines of the Mine Hill and Schuylkill Haven Railroad Company; and public water

* Memoir prepared by Henry H. Quimby, M. Am. Soc. C. E.

† *Proceedings, Am. Water Works Assoc.*, Vol. 24 (1904), p. 341.

supplies in Southern New Jersey, Mount Sterling, Ky., Red Bank, N. J., and Cumberland, Md. In November, 1898, at the request of the General Committee on Water Supply of New York, N. Y., he advised respecting the further utilization of the Croton water-shed, and the necessity of developing other sources of supply, and, in 1909, he investigated the plans and prospects of the Rochester and Lake Ontario Water Company, Rochester, N. Y.

Mr. Trautwine was methodical in his habits and systematic in his business, studying efficiency and ways of minimizing the time and effort necessary to accomplishment, thus finding time outside his professional work to take a useful part in civic activities. His interest in the community life was constant and his views were always constructive.

He was of a genial disposition, interested in life and its philosophy, a close observer of events, and a shrewd practical interpreter of the developments of the times. He was broadminded in his views of social customs and tendencies, tolerant of the idiosyncrasies of his fellows, and always kindly and helpfully disposed.

Mr. Trautwine had a happy facility in public speaking, being fluent and clear, with his subject matter logically arranged. He was ready witted and convincing in argument; his contribution to the discussion of an engineering paper was always practical and illuminating; and he was quick to see and adept in pointing out any humorous reference in an otherwise dry scientific question.

Mr. Trautwine was a life member of the Franklin Institute; a member, former Secretary, and Past-President of the Engineers' Club of Philadelphia; member of the American and the New England Water Works Associations; and an Associate of the Institution of Civil Engineers, London, England.

He was married on May 23, 1872, to Lucy L. Smith, who, with their son, John C. Trautwine, 3d, M. Am. Soc. C. E., survives him.

Mr. Trautwine was elected an Associate of the American Society of Civil Engineers on December 5, 1888, and a Member on April 26, 1921.

COLIN REED WISE, M. Am. Soc. C. E.*

DIED MAY 19, 1924.

Colin Reed Wise, the son of Uriah Winfield and Henrietta Maria (Post) Wise, was born in Washington, Pa., on November 28, 1845. He was prepared for college under the direction of his father who was Professor of Greek and Latin in Mercer University, Penfield, Ga., where the family lived from 1855 to 1865. He entered Mercer University in September, 1861, but was obliged to leave in November, 1863, or be conscripted into the Confederate Army. He was on detail duty until the close of the Civil War, in hospitals at Atlanta and Macon, Ga. In January, 1866, Mr. Wise returned to college where he remained until the end of his Junior year. He then entered Dartmouth College from which he was graduated in July, 1868.

* Memoir prepared by R. S. Wise, Assoc. M. Am. Soc. C. E.

Immediately after his graduation, Mr. Wise was given charge of a school at Dividing Creek, N. J., and later taught at Newport, N. J. His health not being of the best, he resigned his position and, in 1869, joined a corps of engineers which was making surveys for a railroad in Northern New Jersey. The following year he was appointed an Assistant Engineer on the location and construction of the Northern Pacific Railroad in Minnesota.

On the completion of his work in Minnesota, in 1871, Mr. Wise returned to the East and was made Resident Engineer of the Hackensack and New York Extension Railroad, in Rockland County, New York; in 1873, he was appointed Chief Engineer of the railroad. On its completion in 1875, he entered the service of the New York, Lake Erie and Western Railroad Company and was engaged in the preparation of a general inventory of the property of that road. In 1877, he was appointed Assistant Engineer in connection with the construction of the New York Elevated Railroads in Greenwich Street and in Third and Ninth Avenues, New York, N. Y.

On August 18, 1880, Mr. Wise began the work of locating the New York, West Shore, and Buffalo Railroad, later having had charge of the construction of the Bergen County Division. Soon after the construction was finished, he was employed by the contracting firm that built the West Point Tunnel and the section of the railroad adjacent thereto, to prepare a statement of the work done by the firm, which statement resulted in the construction company paying the contractors a considerable sum of money as extras.

Mr. Wise was then sent to Georgia by Messrs. J. and W. Seligman and Company to inspect and appraise the Brunswick and Albany Railroad and other railroad properties in that State. On the re-organization of the Brunswick and Albany Railroad Company as the Brunswick and Western Railroad Company, he was made Chief Engineer and Superintendent of Construction. Afterward, as Assistant General Manager, he had charge of road maintenance and for a short time acted as General Manager. Messrs. Seligman and Company then sent Mr. Wise to Indian Territory to engage in work on an extension of the St. Louis and San Francisco Railroad to Paris, Tex., and, subsequently, he was appointed General Engineering Agent in charge of the construction of a branch line from Wichita to Ellsworth, Kans.

During 1888, Mr. Wise was engaged in an appraisal of the construction work done by the contractor on the Washington Bridge across the Harlem River, New York, and on the sewerage and water-supply systems of the Hackensack Water Company of New Jersey.

In 1889, he formed a partnership with Robert M. Watson, M. Am. Soc. C. E., and was engaged in municipal engineering work, sewer design, sewage disposal, water supply, etc. The firm designed sewerage systems for Liberty, N. Y., Rutherford, East Rutherford, Carlstadt, Oradell, Millville, Madison, and Garfield, N. J., and also prepared plans for sewage disposal plants for six of these towns, as well as plans for sewage disposal systems for a large number of manufacturing establishments. The firm also planned and superintended the construction of water-works systems for Wallington, Garfield, Hawthorne, North Arlington, Kingsland, and Lyndhurst, N. J., and Pearl River, N. Y. In addi-

tion, it prepared the plans for, and had charge of the construction of, the Paterson-Passaic-Hackensack Electric Railroad, the Paterson-Passaic-Hoboken Electric Railroad, and the Passaic-Newark Electric Railroad; designed all car barns, bridges, etc.; prepared plans for a trunk sewer and sewage disposal plant for Passaic and Bergen Counties, at the request of the Passaic Valley Sewerage Commission, which plans however were abandoned; and constructed the present Passaic Valley Trunk Sewer from Paterson to Newark, N. J. Mr. Wise was employed by the Commission to make all surveys in Bergen and Passaic Counties and the investigations, etc., in relation to the trunk sewer.

He served as City Engineer for Passaic, N. J., from 1892 until his death on May 19, 1924, with the exception of three years, when he was County Engineer for the County of Passaic. He was also Engineer for Acquackanonck Township, New Jersey, for 12 years, for Garfield, N. J., for 14 years, and for Wallington, N. J., for 10 years. During this time his firm (Wise and Watson) had charge of the building of several steel and concrete bridges across the Passaic River, reinforced concrete culverts throughout Passaic County, storm-water drains, undergrade crossings, and was engaged in general municipal engineering work.

In 1875, Mr. Wise was married to Serena Sherwood, of Spring Valley, N. Y. Mrs. Wise died on September 2, 1903. On December 8, 1904, Mr. Wise was married to Mrs. Lizzie Hutton, of Nanuet, N. Y., who, with two daughters and a son by his first marriage, survives him.

Mr. Wise had been prominent socially, professionally, and politically in Passaic for more than half a century. He was known throughout the State of New Jersey as a leader in his profession and was widely consulted in relation to engineering projects in the East. Aside from his professional work, Mr. Wise was active in the civic affairs of the community in which he lived. He was interested in athletics and was a member of the old Passaic Rod and Gun Club.

Mr. Wise was elected a Member of the American Society of Civil Engineers on April 6, 1904.

HUGH LESTER MAYERS, Assoc. M. Am. Soc. C. E.*

DIED OCTOBER 25, 1924.

Hugh Lester Mayers was born in Kennedy, Ala., on May 8, 1892. He attended the Vernon High School in Lamar County and was graduated from the Alabama Polytechnic Institute in 1914, with the degree of Bachelor of Science in Civil Engineering.

Following his graduation, Mr. Mayers served as Rodman and Instrumentman with the Alabama Power Company from August, 1914, to August, 1915, and as Rodman and Assistant with the Southern Railway Company, from August, 1915, to December, 1916. In January, 1917, Mr. Mayers entered the Chicago Office of the Illinois Central Railroad Company as Draftsman where

* Memoir prepared by W. S. Keller, M. Am. Soc. C. E.

he remained until the United States entered the World War. Receiving a leave of absence, he returned to Alabama and enlisted as a Private in the U. S. Army. Two months after his enlistment, he was sent overseas with Company B, 306th Engineers, 81st Division, and soon thereafter was commissioned a Second Lieutenant. After being honorably discharged Mr. Mayers returned to Chicago and resumed his work with the Illinois Central Railroad Company.

In April, 1920, he was appointed to the position of Resident Engineer in charge of bridge construction near Montgomery, Ala., by the State Highway Commission of Alabama. He was one of the most efficient engineers connected with the State Highway Department, always loyal to the State and conscientious in the performance of duty. In July, 1923, he resigned this position to accept a more lucrative one as Consulting Engineer with the Stanley and Singer Construction Company, Contractors, of Lafayette, Ala., in charge of all engineering in connection with Federal Aid bridge and road work, which position he held at the time of his death.

On Saturday morning, October 25, 1924, Mr. Mayers and Mr. T. E. Stanley were inspecting a proposed State road project in Russell County, Ala., and while crossing the Seaboard Airline Railway tracks near Hurtsboro, in an automobile, were struck by a train and instantly killed. Both men were very popular in the State, Mr. Stanley being one of the most prominent road contractors in Alabama.

Mr. Mayers was highly esteemed by all who knew him and his scores of friends were greatly shocked to learn of his untimely death.

The State Highway Commission in Session on November 12, 1924, passed the following resolutions:

"Whereas, T. E. Stanley as Contractor and Hugh L. Mayers as Engineer, have been connected with the State Highway Department for a number of years, Mr. Stanley being a contractor of high standing and integrity and Mr. Mayers being directly with this Department for a number of years, and later Engineer for the firm of Stanley and Singer and at all times known for his high standing as a gentleman and engineer of ability and rugged honesty; and

"Whereas, The State Highway Commission has learned with profound sorrow of the untimely death of these two excellent men on October 25, 1924, at Hurtsboro, Alabama,

"Now, Therefore, Be It Resolved, that the State Highway Commission in session on this the 12th day of November, 1924, goes on record as greatly deplored the loss of Messrs. Stanley and Mayers, their passing being an irreparable loss to their families and a misfortune to the State Highway Department.

"Be It Further Resolved, that our deepest sympathy be expressed to the bereaved families of our departed friends, and that a copy of these resolutions be spread on the minutes of the Commission."

Mr. Mayers was elected an Associate Member of the American Society of Civil Engineers on February 25, 1924.